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Marine ecological baseline report for Amal/Crab Bay Tabu Eria, Malekula Island, Vanuatu

By Francis Hickey

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Abbreviations

AKTE	Amal/Krab Bay Tabu Eria
AIMS	Australian Institute of Marine Sciences
CF	Community Facilitator
CITES	Convention on International Trade in Endangered Species
COT	crown of thorns starfish
DoF	Department of Fisheries
GBR	Great Barrier Reef
GPS	global positioning system
HWS	high water spring tides
IK	indigenous knowledge
IWP	International Waters Project
LWS	low water spring tides
MC	Management Committee
MPA	marine protected area
RFDO	Rural Fisheries Development Officer
scuba	self contained underwater breathing apparatus
SPREP	Secretariat of the Pacific Regional Environment Programme
TEK	traditional ecological knowledge
TK	traditional knowledge

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Executive summary

An ecological baseline survey of the Amal/Crab Bay Tabu Eria (AKTE) was performed between November 2004 and May 2005. Resources were surveyed with the assistance of Community Facilitators (CFs), and under the direction of the AKTE Management Committee (MC); surveyed resources included land crabs, terrestrial flora, mangroves, avifauna, mammals, finfish, shellfish, turtles and dugongs. Available literature regarding these resources and their distrubution within Vanuatu was reviewed and summarised, and traditional and local knowledge documented, including vernacular names for resources. The impacts of tectonic uplifting affecting mangrove zonation and nearshore reefs was also documented.

Amal/Crab Bay is an area of high biodiversity among the vast network of coconut and cattle plantations initiated during colonial times in Central Malekula. The lowland coastal forests and extensive mangroves of the Amal/Crab Bay area, which are part of the largest concentration of mangroves in Vanuatu, support a rich diversity of marine and terrestrial life.

Land crabs (*Cardisoma carnifex* and *C. hirtipes*) have been identified by surrounding communities as priority resources requiring improved management. They were surveyed for abundance (including burrow density, baited counts and timed counts) within various sub-habitats in the AKTE. Burrow density compares well with the range of densities found in other parts of the world where land crabs are considered abundant. The crab abundance data will serve as a baseline for future counts and for monitoring changes in density. Seven species of true mangroves were found within the AKTE, along with six species of mangrove associates; mangrove zonation was characterised, including anomalies associated with tectonic uplifting. Over 50 species of terrestrial flora were documented within the AKTE. The finfish community was characterized across the three main marine habitat types: mangrove, fringing reef (including seagrass, coral pavement and rubble areas) and fringing reef drop-offs. Diversity was highest in reef drop-offs, followed by mangroves and lastly fringing reef seagrass, coral pavement and rubble complexes. The importance of mangrove habitat for the juvenile phase of some reef fishes was documented. Approximately 50 species of shellfish were noted within various habitats of the AKTE, and their vernacular terms documented. The traditional uses of mangroves and the terrestrial flora were aslo documented. Over 30 species of avifauna were documented residing in and around the AKTE. At least two species of turtles (green and hawksbill) are regularly found feeding in the AKTE and the hawksbill turtle was confirmed as nesting there. Between six and ten dugongs are estimated to reside in the AKTE.

The training given to the CFs will assist in continuing to monitor the various resources with minimal assistance from outside sources. The effectiveness of the use of traditional ecological knowledge (TEK) in monitoring and sustainably managing resources was highlighted, and examples of how TEK may be used for management were provided to community members. Vernacular terms in the three languages used in the area, where available, were also documented for most of the resources surveyed. The erosion and loss of vernacular languages, particularly for terms associated with the classification of the marine and terrestrial species found in this area, was highlighted throughout this survey.

Based on the training given to CFs, a monitoring plan is presented as part of this report. Recommendations for resource management within the AKTE are also provided, as well as lessons learned that may be applied to resource management efforts at the national and regional level.

1 Introduction

1.1 Objectives

Prepare and conduct an ecological baseline survey of the key fisheries resources at Crab Bay in particular land crabs, for the development of a management plan, and to support the involvement of the community in baseline assessment and monitoring work. The full terms of reference for the Marine Ecological Baseline Survey are given in Annex 1.

1.2 Geography

Vanuatu is a Y-shaped archipelago in the southwest Pacific (Fig. 1), extending approximately 1,200 kilometres (km) southeast to northwest, and including some 80 islands with a total land area of 12,190 square km (km^2). Vanuatu extends from 13° S to 22° S (ownership of the two southernmost islands of Mathew and Hunter is disputed with France). The largest islands are Espiritu Santo (3,937 km^2, accounting for 32 % of the total land area), Malekula (2,034 km^2), Erromango (898 km^2) and Efate (877 km^2). Vanuatu's Economic Exclusive Zone covers 690,000 km^2.

1.3 Population

The population is predominantly Melanesian in origin (but includes people of Polynesian descent on Polynesian outliers) with a total of 186,678 according to the 1999 census;[1] the estimated population in mid-2004 was 215,800 (SPC 2004). The average growth rate over the 10 years preceding the census was 2.6%. In 1999 urban residents accounted for 21.5% of the populace, and rural residents for 78.5%; in 2004 the estimated the urban growth rate (4.2%) was almost double the rural growth rate of 2.2% (SPC 2004). The rural population lives a predominantly subsistence lifestyle based on agriculture production supplemented with protein from livestock (e.g. pigs, chickens, and cattle) and freshwater and marine resources. Traditionally, most marine resources were derived primarily from nearshore reefs and other highly productive nearshore areas (including estuaries, seagrass meadows and mangroves). People residing inland largely depended on freshwater resources such as eels, fish and prawns in addition to commensals such as pigs and chickens as sources of animal protein.

1.4 Geology

Geologically, Vanuatu is part of an island chain that originates in New Zealand and terminates in Papua New Guinea. Most of the islands are the summits of volcanic mountains that rise more than 3000 metres (m) from the ocean floor. The islands are on the western edge of the Pacific Plate where the adjacent Australian plate is subducted beneath it, forming the 8000 m deep New Hebrides Trench, which is parallel and to the west of the archipelago. Frequent earthquakes and volcanic eruptions occur, due to Vanuatu's proximity to the plate boundaries. Vanuatu has nine active volcanoes, seven on land and two undersea (Bigelow 2001).

The islands making up the archipelago are relatively young, and were formed during four main periods of volcanic activity. The oldest islands of Malekula (Fig. 2), Santo and the Torres were formed over 22 million years ago, while Pentecost and Maevo were formed between 5 and 11 million years ago (Bigelow 2001). The small volcanic islands of Futuna and Merelava are between 2 and 5 million years old; the remaining islands were formed during the last 3 million years. The islands are composed of volcanic ash and coral. The land building process is ongoing, with 20% of the current land surface estimated to have formed in the last 200,000 years through uplifting (Nimoho 1997). Many of the islands have stepped limestone plateaus.

[1] Vanuatu key social statistics: see http://www.spc.int/prism/country/vu/stats/Social/social.htm.

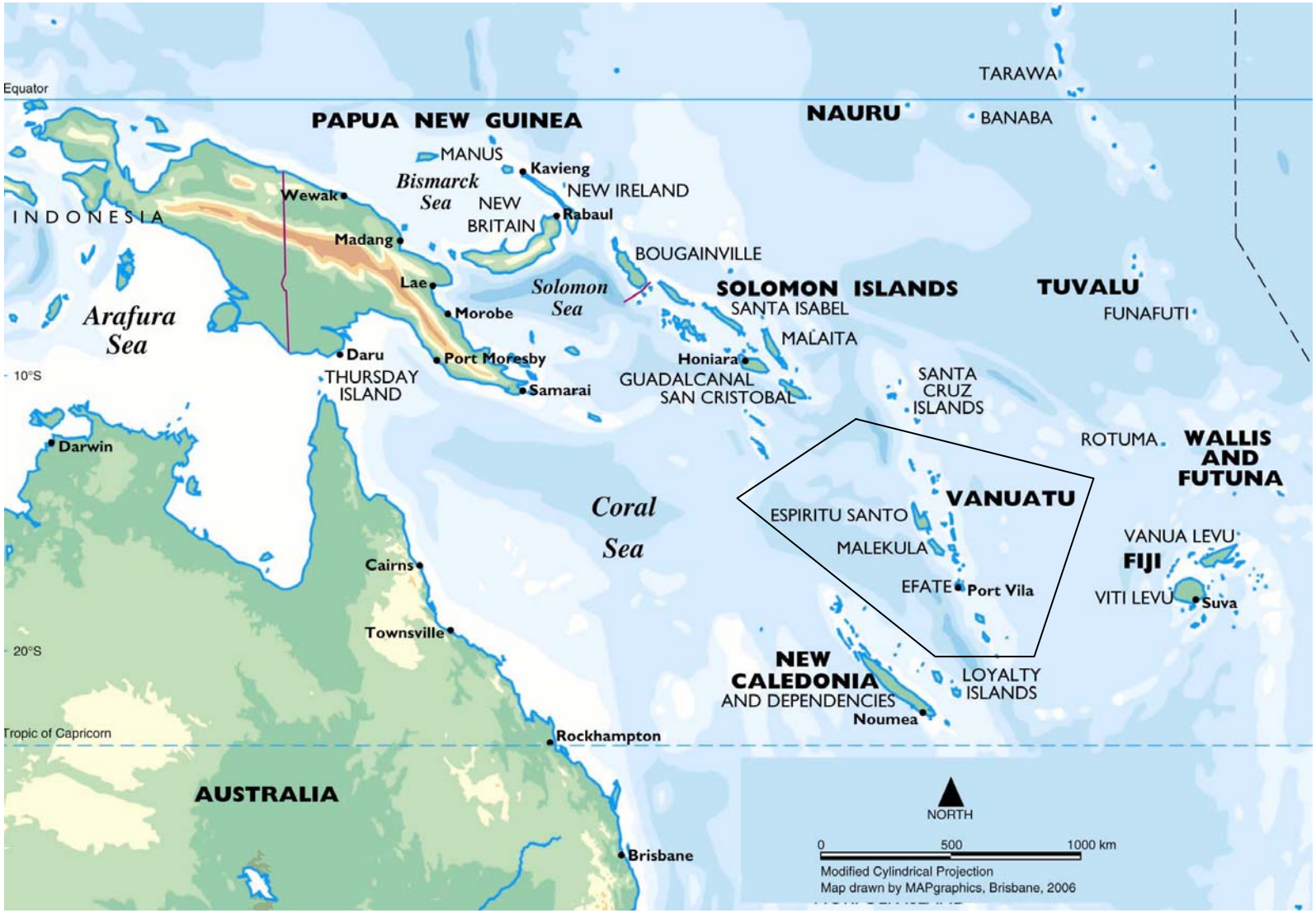

Figure 1: Vanutu location map

Due to the volcanic origin of the islands and steep slopes, there are no extensive barrier reefs or lagoon areas found within the group. Coral formations primarily occur as fringing reefs with an abrupt transition to deep oceanic waters. There is one atoll found in the archipelago, known as Rewo or Reef islands in the Banks Group, and uninhabited since about 1950.

Current rates of tectonic uplift are variable within the group, with an estimated annual east to west movement of 10–12 cm in the southern islands, 4–5 cm on Efate and slowing to 0.9 cm on Malekula (Charlie Douglas, Department of Geology and Mines, pers. comm.). The south to north gradient in rates of lateral movement of the underlying tectonic plate is due to the resistance offered by a ridge of thickened uplifted crust known as the D' Entrecasteaux Fracture Zone, which runs perpendicular to the archipelago west of south Santo and north Malekula. The resistance to subduction offered by this ridge is believed to be responsible for the extreme elevation of the frontal arc at Santo and Malekula and thus shoaling of waters from the New Hebrides Trench (MacFarlane and Carney 1987); it also results in a higher frequency of earthquakes in this area of Vanuatu.

During earthquakes and the subsequent release of pressure between tectonic plates, vertical uplifting may occur, the extent of which depends on the local fault structure. The fault system within the Santo and Malekula area is extremely complex due to the resistance to subduction offered by the D'Entrecasteaux Fracture Zone; while some areas may be uplifted during earthquakes, others may subside (Charlie Douglas, Department of Geology and Mines, pers. comm.). This level of tectonic activity and resultant uplifting has specific impacts on the Crab Bay area and will be discussed in greater detail in the section on mangroves.

1.5 Biodiversity

Older islands generally support greater biodiversity and endemism as younger islands have had less time for speciation to occur. Larger islands also generally provide a greater range of habitats and thus potentially support greater biodiversity and endemism. Other factors affecting biodiversity include latitude, climate and altitude, geographical barriers (e.g. mountain ranges, large distances between islands), occurrence of natural disturbances (e.g. cyclones, prolonged droughts, tectonic uplift) as well as human induced disturbances (local extirpations and extinctions, use of fire, and introduction of pests like rats, birds and invasive species).

Lapita people were the earliest colonists to these islands, arriving some 3,000 years ago. To date, the archaeological evidence for Lapita-induced extinctions — which are normally found within the first 300 or so years of settlement, when environmental impacts were typically most severe — include a small endemic, terrestrial crocodile (*Mekosuchid* sp.) and a small number of land birds (Bedford 2000). The latter include a large pigeon (*Dacula* sp.) and extirpations of the endemic kingfisher (*Halcyon farquhari*) and a starling (*Aplonis* sp.) on Erromango. On Malekula a new species of now extinct parrot (*Ecletus* sp.) appeared in the earliest archaeological records, while it appears that a large flightless rail (*Porzana tabuensis*) has more recently been possibly extirpated on Malekula. On Efate, the disappearance of a hawk (*Accipiter* sp.) and a megapode (*Megapodius alimentum*) are associated with early human contact. The endemic kingfisher (*H. farquhari*) was later extirpated on Efate (Bedford 2000).

Recent research conducted in Hawai'i indicates that (at least in some cases), impacts on avifauna associated with early colonization within the Pacific may have resulted primarily from habitat alteration by rats that were introduced by the first colonists, rather than direct predation of avifauna by people (Athens et al. 2002). Avian viruses that accompanied the introduction by the first colonists of domesticated fowl may also have been responsible for some impacts to avifaunal populations (Matthew Spriggs, pers. comm.).

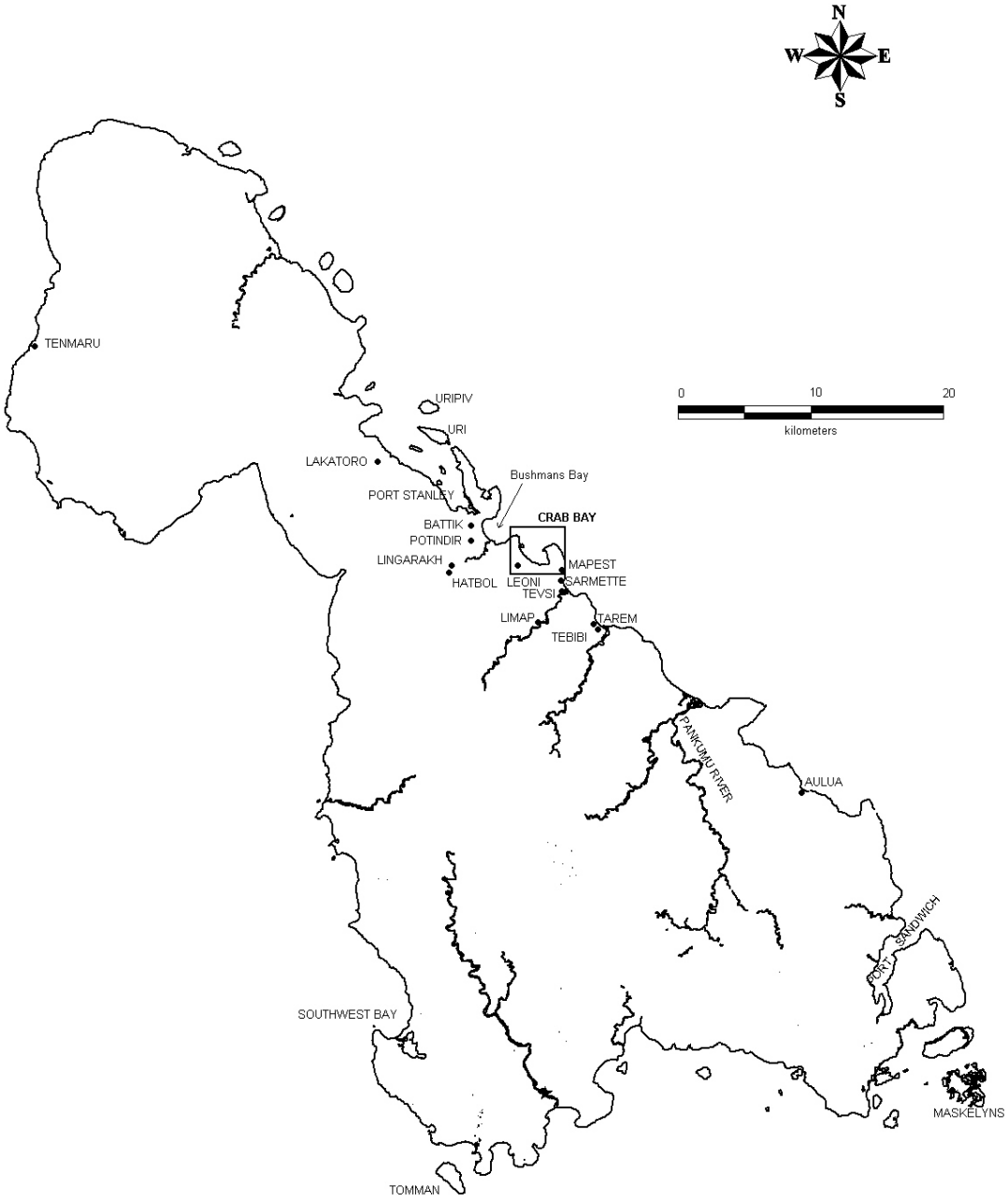

Figure 2: Map of Malekula Island

A much higher level of extirpations and extinctions, as has been found in many Pacific Islands after initial colonization, may yet be revealed with further archaeological excavations on earliest Lapita sites (Stuart Bedford, pers. comm.). Early Lapita village sites, in which the greatest environmental impacts are likely to have occurred, have only recently been found and excavated in Vanuatu.

Anecdotally, it also appears that the two largest species of giant clams (*Tridacna gigas* and *T. derasa*) may have also been locally extirpated from most of the archipelago at some point in Vanuatu's recent history (Done and Navin 1990), although comprehensive surveys to confirm this have yet to be performed.

Vanuatu and the Santa Cruz Island group (which is politically part of the Solomon Islands) together form a natural biogeographical unit which is isolated by both distance and deep oceanic troughs from the larger neighboring islands (which are today part of the main Solomon Islands and New Caledonia). These links are most apparent with the bird populations. Bregulla (1992) describes the birds of Santa Cruz as an outlier of Vanuatu's birds with some immigrants from Fiji and the main Solomon Islands chain. Vanuatu's flora has strongest links with Solomon Islands, with fewer elements from Fiji and even fewer from Australia or New Caledonia (Wheatley 1992). Levels of endemism are currently estimated at 10–15% for vascular plants, 8 % for mammals, 11 % of land and freshwater birds, 23% of reptiles and between 6% (butterflies) and 78% (land snails) for various invertebrate groups (Nimoho 1997).

Vanuatu also has two notable endangered species found at the periphery of their distribution; the estuarine crocodile (*Crocodylus porosus*) and the dugong (*Dugong dugon*). While the crocodile population is currently marginal and restricted to the Banks Islands (it has ranged as far south as Ambae and Maevo in the last five years), the dugong is found throughout most of the archipelago and its population, including that found in Crab Bay, is considered secure and stable (Chambers et al. 1989).

A list of endemic animal species of Vanuatu documented to date by the Vanuatu Environment Unit is given in Annex 2. Species found within the AKTE are included in this annex.

1.6 Nearshore marine resources and management

1.6.1 Habitat

Vanuatu has a total of 44,800 hectares (ha) of nearshore habitats (i.e. areas less than 10 m in depth), which includes fringing reef, mangroves, seagrass meadows and estuarine habitats. Most coastal fisheries occur in this area. Fifty-three percent of this area is concentrated among Malekula (10,100 ha), Efate (8,070 ha) and the Banks/Torres islands (5,370 ha, excluding Reef Island) (Cillaurren et al. 2001). Despite the relatively limited areas of fringing reefs in Vanuatu (which is characteristic of steep volcanic islands), the islands support an ecosystem that provides important sources of animal protein to rural villages. The largest concentration of mangroves is found along the eastern coast of Malekula in the Port Stanley/Crab Bay area, along with those of southeastern Malekula around Port Sandwich and the Maskelyne Islands (see Fig. 2).

Nearshore environments — including coral reefs, mangroves, seagrass beds, lagoons and beaches — are important socioeconomically, and are all considered critical habitats in the Pacific Region. These habitats and their resources are susceptible to pollutants, population growth, development pressure and overfishing (Bleakley 2004). In addition, marine turtles, crocodiles, marine mammals, fishes (including sharks), invertebrates (including endangered species such as giant clams (*Tridancna* spp.) and commercialized shellfish such as trochus (*Trochus niloticus*) and green snail (*Turbo marmoratus*), as well as seabirds, are all considered critical species (Bleakley 2004). Relevant to this survey, all of the above critical habitats and fauna (with the exception of crocodiles) are found within the study area of Crab Bay.

1.6.2 Use of marine resources

Cillaurren et al (2001) estimated that annual production by village fisheries from nearshore habitats in 1983 totaled 2,849 tonnes (t), including 47% finfish, 31% shellfish, 19% crustaceans, and 2–3% cephalopods. Given the 60% increase in population since 1983, the significantly increased interest in generating revenue from marine resources, and the increased use of introduced fishing gear,[2] the volume of nearshore marine resources harvested annually

[2] Between 1983 and 1993, the number of gill nets doubled with the household ownership rate rising from 14% to 27% (Cillaurren et al. 2001).

is likely to have more than doubled. The economic value of the subsistence catch to the national economy, in terms of informal trading as well as import substitution, is often overlooked (Dalzell et al. 1996); subsistence harvests also make a positive contribution to nutrition in rural areas. The harvesting of commercial resources (including trochus, green snail and bêche-de-mer) also provides significant revenue sources for rural communities, and generates foreign exchange, but Dalzell et al. (1996) indicate that the subsistence catch from nearshore reefs in most Pacific nations, including Vanuatu, is worth more in economic terms than commercial nearshore catches.

1.6.3 Management and conservation

Aside from some national fisheries regulations (which impose size limits on some nearshore commercial resources such as trochus and green snail, protect turtle nests and control the export of aquarium trade products), the management of the nearshore reefs is primarily vested with the traditional reef custodians, through customary marine tenure (CMT). CMT is legally recognized in Vanuatu in Chapter 12 of the Constitution, which states:

> Article 73: "All land in the Republic of Vanuatu belongs to the indigenous custom owners and their descendents."
>
> "Land" is further defined in the Land Reform Act to include …. "land under water including land extending to the sea side of any offshore reef but no further……"
>
> Article 74: "The rules of custom shall form the basis of ownership and use of land in the Republic of Vanuatu."

These articles provide customary owners the right to manage their land and reefs as they have traditionally done for centuries through the use of taboos and other fisher behavior restrictions following local cosmologies. Research into traditional resource management in Vanuatu reveals a strong heritage of managing resources through CMT and a combination of traditional beliefs and practices, which included privileged user's rights, species-specific prohibitions, seasonal closures, food avoidance and closed areas (Hickey in press).

Examples of these practices include the placement of marine closures or taboos for up to five years or more upon the death of a chief, or any clan member, or the ordination of a traditional leader; seasonal prohibitions on consuming certain fisheries resources following agricultural cycles; respect and avoidance of "tabu places" (i.e. areas of spiritual significance); and behavioral restrictions for fishers that limited fishing effort, including those associated with totemic restrictions (Hickey in press). The Vanuatu Department of Fisheries, Vanuatu Cultural Centre and the Vanuatu Environment Unit actively support these customary practices and recognize CMT as a viable, decentralized system of resource management that fosters a sense of responsibility among communities to manage their own resources well. Traditional leaders and reef custodians continue to see the management of resources under their tenure as their traditional responsibility and draw upon well established systems of customary land and reef tenure to control access and harvesting from their land and reefs.

A survey conducted in 1993 and 2001 of village-based marine resource management among 21 different villages spread over 5 islands, including central Malekula, showed a broad range of management measures (locally referred to as taboos, or bans) including species-specific closures, gear restrictions and area closures, including long-term area closures (Hickey and Johannes 2002; Johannes and Hickey 2004). Examples of these village-based management measures included (i) restrictions on harvesting trochus and green snail, sea cucumbers, turtles, giant clams and crabs; (ii) fishing ground closures; (iii) spearfishing and net restrictions; and (iv) restrictions on destructive methods that destroyed reef habitat. Increasing population and pressure on land and reefs, commercialization of resources, emergence of the cash economy, and widespread introduction of new fishing gear technology caused the number of management measures imposed among these 21 villages to more than double in the 8 years between the surveys (Johannes and Hickey 2004).

While compliance with these measures was generally very good among most of the communities surveyed, where internal community conflicts regarding land tenure and leadership were unresolved, they were found to significantly undermine effective management of marine resources (Johannes and Hickey 2004). When used in conjunction with villagers' traditional knowledge (TK), data-less management techniques (Johannes 1998a) — which include the use of popular theatre and which provide culturally appropriate awareness of marine resource lifecycles and ecology — were shown to have a positive impact on resource management (Johannes and Hickey 2004). The application of these cooperative management techniques began in Vanuatu in the early 1990s with the Department of Fisheries trochus enhancement program (Amos 1993) and quickly spread to cover other nearshore resources (Johannes 1998b; Johannes and Hickey 2004).

More recently, outside groups such as development agencies and non-governmental organisations (NGOs) have began to pursue conservation goals through more western models by encouraging conservation areas (CAs) and marine protected area (MPAs). Most rural communities remain suspicious of these models due to concerns that they impose unreasonable constraints on fishers' behavior and pose a threat to their livelihood (Bleakley 2004). These models also originate from industrial countries lacking the well established cultural institutions of custom land and marine tenure, and tend to overlook the strong sociocultural and subsistence links Pacific people historically have with their resources (Hickey in press).

Given Vanuatu's cultural context and the appropriateness of traditional management models to rural village settings, resource management goals may be best achieved by acknowledging, supporting and strengthening indigenous models, while assisting in the process of adapting these to contemporary socioeconomic circumstances; further support can also be given to cooperative management efforts, and to capacity building for traditional leaders to assist them in fulfilling their resource management roles. The benefits of this approach include cultural appropriateness and community capacity building, which together promote a stronger sense of identity and ownership over the initiative and hence sustainability and self-reliance. In addition, area and species-specific TK from within the community may be mobilized to enhance resource management, adding further to the sense of community empowerment and reducing dependency on outside sources for resource management. Examples of such TK include when and where key species are known to migrate and aggregate for spawning purpose and the location of critical feeding and resting areas; possession of such knowledge allows fishing pressure to be reduced during spawning periods or at key feeding and resting locations through the introduction of harvest prohibitions.

Reinforcing and strengthening the traditional management approaches and positioning this resource management initiative within the existing cultural framework has the additional advantage of serving to strengthen traditional leadership and mutual respect within communities, which has positive effects on other aspects of village societies. In addition, most central and provincial governments in Pacific Island countries have limited capacity (in terms of human and financial resources) to monitor and enforce resource management-related restrictions, particularly in archipelagoes with poor and/or expensive travel linkages, which highlights the importance of recognizing and strengthening the capacity of communities to fulfill this role. IWP-Vanuatu has adopted this approach in strengthening the Amal/Crab Bay Tabu Eria (Hickey 2006), in keeping with the stakeholder community's objectives of strengthening, revitalizing and maintaining their traditions.

1.7 Survey methodology

A preliminary field trip to the Crab Bay area was undertaken between 24 November and 10 December 2004. A list of resource people consulted is given in Annex 2

The individual methodologies employed for the various aspects of the ecological baseline survey are outlined in the respective sections below.

2 Documentation of terrestrial flora

2.1 Rationale

The rational for documenting the terrestrial flora, including mangroves, was multifold.

1) The ACTE includes substantial terrestrial areas with a number of resources with social and economical importance.

2) Crabs, both white (*Cardisoma carnifex*) and black (*C. hirtipes*), are primarily terrestrial, with a relatively brief marine larval phase. They therefore rely heavily on the terrestrial habitat within and around the ACTE for both feeding and burrowing (which is especially important during winter months while molting), and as a spawning aggregation site for releasing larvae into the sea.

3) Mangroves, identified as a high priority resource to be protected due to (i) their importance to crabs; (ii) their importance to communities for many uses, including as a building material and source of fuelwood; and iii) their importance as a habitat for fish, shellfish and other resources (e.g. mud crab, flying foxes, and birds). Mangroves were included in the terrestrial survey as they were more easily accessible from inland areas on most tides.

4) To assist with training in introducing the concept of recording data from transects, comparing data between transects and relating these comparisons to habitat or other differences.

2.2 Methodology

Community Facilitators (CFs) from the communities of Hatbol, Lingarakh, Leoni and Port Indir were selected by the MC to assist with the terrestrial botanical surveys. A briefing was provided to the CFs that included (i) the purpose of the botanical surveys (to identify which flora, primarily trees and shrubs, were present in (and thus protected by) the ACTE), (ii) how the surveys would be performed (by sampling a transect) and (iii) the type of information to be collected (Bislama and vernacular names, scientific names, samples of species whose scientific or vernacular name was unknown and the traditional uses of the plants observed). The value of monitoring these transects over time to detect changes in species composition — in response to both natural events such as cyclones, climate change, and tectonic uplifting or from human-induced changes such as fires — was made clear to the CFs.

The vernacular names of the flora identified were collected in the field and recorded in a waterproof data book. Botanical samples were collected for those species that could not be given a vernacular name in all three local languages. The CFs tagged these samples with a number and took them back to their respective villages in the evening where they worked with older members of their communities to identify the correct vernacular term for the plants, as well as their traditional uses. Botanical samples that could not be scientifically identified to species level in the field were taken to the Fisheries/Forestry offices and assigned a sample number, tagged and placed in a plant press for the duration of the field trip. These samples were then lodged with the Herbarium Curator at the Department of Forestry in Port Vila for identification.

Terrestrial transects on the Amal headland were selected with the assistance of the CFs as well as the Rural Fisheries Development Officer (RFDO) and Forestry Extension Officer (FEO), based on two criteria: (i) the sites were easily identifiable for resurveying without the use of a GPS; and (ii) the sites were representative of the flora of the area.

2.3 The flora of Vanuatu

Vanuatu's moist, tropical climate typically supports luxuriant, evergreen rainforests. The

islands' young age, their geographical isolation and the destructive and regular effects of cyclones result in flora of limited diversity, however, relative to that of Solomon Islands and Papua New Guinea (PNG). The region extending from PNG to Malaysia is one of the most botanically diverse on earth (Wheatley 1992), and most of Vanuatu's flora originates from this centre of diversity, having dispersed via the Solomon Islands; in addition, some of Vanuatu's flora originated in Fiji, and a few species in Australia and New Caledonia (Chew 1975).

Vanuatu's flora has both less diversity than neighbouring countries (e.g. Solomon Islands, Fiji and New Caledonia, as evidenced by the presence of fewer families and genera), but also less endemism (Wheatley 1992). In addition, those families that are well represented in Vanuatu have a very wide geographical distribution. These factors suggest that Vanuatu has a young immigrant flora, with colonisation of the archipelago having taken place both rapidly and recently. This is supported by geological studies indicating that 90% of Vanuatu's present land area rose from the seabed in the last 1.5 million years (Mallick 1975). Given Vanuatu's relative geographical isolation, this is a short period for colonisation and endemism to occur. Endemism has occurred primarily at the species level, with no families and only one genera (*Carpoxylum macrospermum*) known to be endemic. Chew (1975) reported that 15–20% of species are endemic, but noted that this may be reduced once taxonomic revisions are complete. The Department of Forestry currently estimates that some 1,300 species of trees and shrubs are present in Vanuatu, of which roughly 200 (10–15%) are endemic (Sam Channel, Department of Forestry, pers.comm.)

A hypothesized consequence of reduced diversity is that many species increase their ecological amplitude (i.e. they may be found in a much wider range of habitats than would be true in areas with greater biological diversity). This breadth of ecological amplitude makes it more difficult to distinguish discrete altitudinal zones than it is where forests are more diverse (e.g. in northwest Vanuatu). In addition, altitudinal zonation in Vanuatu is more compressed relative to Solomon Islands or PNG, possibly due to Vanuatu's higher latitude; species that are found above 500 m in the Banks Islands may be found at 300 m on Efate and at only 50 m on Aneityum.

2.3.1 Moist lowland forests

Moist evergreen rainforests are the natural climax vegetation over most of Vanuatu's lowlands, and comprise the most floristically diverse and structurally complicated of Vanuatu's forest types (Wheatley 1992). In their natural state these forests consist of a mosaic of climax and secondary types that alternate in a perpetual balanced cycle. The climax lowland forests of central Vanuatu typically include large trees such as *Syzygium* spp*., Dysoxylum* spp., *Pterocarpus indicus* and *Instia bijuga*, while the groundcover includes shade tolerant species of the Rubiaceae family (Wheatley 1992). When the canopy is broken by cyclones or shifting agriculture, fast growing pioneer species such as *Macaranga* spp*., Alphitonia* sp*., Commersonia* spp*, Grewia malococca, Gyrocarpus americanus, Hibiscus tiliaceus* and shrubs of the Urticaceae move in to colonise the area. These species then give way to secondary species that typically include *Elaeocarpus* spp*., Glochidion* spp. and *Ficus* spp. *(*Wheatley 1992 and Sam Channel*,* pers. comm.).

The RFDO and CFs report that some small scale logging occurred in the late 1990s on the Crab Bay side of the AKTE, through use of a "walkabout sawmill". These locally run operations are now common on Malekula, and generally target hardwoods (e.g. *Instia bijuga and Pterocarpus indicus*) typically found in climax lowlands, which are milled into timber for sale locally and export to the capitol.

Numerous botanical introductions have occurred throughout Vanuatu's history, but only a few of these are considered to be invasive forest species. The legume *Leucaena leucocephala*, known as *Kasis* in Bislama, is now found on most islands. It normally does not become invasive in moist forests but may become so in drier areas (Wheatley 1992), such as on the

northwestern side of islands that experience a rain shadow effect. The fast growing climber *Merremia peltata* will often move in to colonise areas disturbed by logging or cyclones, where it covers secondary growth. The regrowth does eventually break through and shade out the climber, but the processes controlling the release is not well understood (Wheatley 1992). Local informants find that cutting the climber back effectively assists the process. Additional alien invasive species include *Cordia* sp., *Lantana* spp. and *Mikania micrantha* (Nimoho 1997).

2.4 Results of botanical sampling within the AKTE

The complete terrestrial transect results for Amal and Crab Bay are listed in Annex 2.1 and 2.2, respectively.

2.4.1 Amal

Transect 1

Transect 1 extended from the foreshore at the western boundary of the ACTE inland to the access road for approximately 120 m (see Fig. 3). From seaward to landward, the following species of mangroves were found: *Avicennia marina, Rhizophora stylosa, Sonneratia alba,* with occasional *R. mucronata* and *Ceriops tagal.* An occasional large *A. marina* was found in the landward area, the result of tectonic uplifting in this area. This zonation of mangroves is typical for this area of Malekula and will be discussed in the section on mangroves.

The mangrove associates were represented by *Derris trifoliata, Xylocarpus granatum and Caesalpinia crista*. Landward of these species the littoral strip or strand flora was represented by *Cordia subcordata, Thespesia populnea, Cocos nucifera, Guetardia speciosa, Instia bijuga, Acacia spirobis, Macaranga tanarius, Murraya paniculata, Gyrocarpus americanus, Premna corymbosa, Elattostachys falcate, Heritiera littoralis, Terminalia litoralis, Ficus* sp.*,* and *Glochidion ramiflorun.*

It is reported that *Cocos nucifera* (coconuts) were planted some 25 years ago by a migrant worker, who later returned to his home island (Kevin Mores, RFDO, pers. comm.). Fortunately, he never cleared the forest to plant. These coconuts can still be found in rows amongst the bush and trees of Amal. They reportedly haven't borne fruit since a cyclone Ivy struck this area in 2002.

The lowland coastal flora found is typical for disturbed coastal lowland areas of Vanuatu, with some secondary and climax growth as documented by Wheatley (1992).

Transect 2

Transect 2 was approximately .25 km from the coast and began in the large mudflat clearing (these areas are discussed further in the Section on Effects of Uplifting) located in the middle of the Amal headland and heading in a southerly direction (see Fig. 3) The species found at the landward edge of this seasonally tidal inundated (during summer months) open area include the mangrove associates *Excoecaria agallocha, Derris trifoliata and Caesalpinia crista* and moves to a mosaic of pioneer, secondary and climax species. These include *Macaranga* sp.*, M. paniculata*, *Thespesia populnea*, *Dysoxylum* spp.*, Instia bijuga* as well as the exotic pioneer vine *Merremia.* This species composition is indicative of recent breaks in the canopy, most probably from cyclones in recent years.

Transect 3

Transect 3 of Amal also originated from the large clearing but ran in a northerly direction. The species composition of this transect shows a similar pattern of mangrove associates giving way to typical strand flora of *Cordia subcordata*, *Guettarda speciosa* and *Pandanus tectorius* to a

mosaic of pioneer, secondary rainforest.

One notable feature of the Amal flora relevant to crab habitat includes a large dense thicket of primarily *burao* (*Hibiscus tiliaceus)* along the southern border (see Fig. 3). Much of this area is nearly impenetrable by people yet is rich with crab burrows with an abundance of detritus available as food. This area thus acts as a natural reserve for crabs.

2.4.2 Crab Bay

The species composition of Crab Bay is typical of lowland coastal forests with evidence of recent disturbances, primarily cyclones and some small scale hardwood extraction, as noted above. Neither of these areas was normally used for gardening purposes, so the disturbances are primarily natural, with the exception of the access road and lane clearance (during colonial times) and later small scale logging. These disturbances are evidenced by the presence of the pioneer and secondary species listed above. The Crab Bay species composition is very similar to that found in Amal.

The leaf litter and fallen, decaying trees, as well as the extensive mangroves (evident in the aerial photos; see Figs. 3 and 4) provide the primary source of nourishment for the high density crab population found in this area.

The vernacular terms and main traditional uses of the flora surveyed in the ACTE area were documented through discussions with the CFs. The CFs were encouraged to hold discussions with their village elders regarding traditional uses when seeking clarification of vernacular terms for the surveyed flora. The results of these discussions were pooled and appear in Annex 3. The main impetus for including this information as part of the ecological baseline survey was to document existing TK for the benefit of the community, who recognize that this knowledge is being eroded and lost, primarily as a result western education (which is taught in either English or French and excludes TK), and the extensive use of Bislama (a Pidjin English invented during colonial times and now the *lingua franca* in Vanuatu).The communities wish to protect and safeguard, for the benefit of future generations, both the resources themselves and the TK associated with those resources.

It should be noted that much of this documentation work and associated training was related to processes as much as results. That is, while the results of this survey are limited (by time), the process of initiating and fostering this sort of inquiry and transmission of knowledge between youth and elders is meant to be ongoing. It is also not intended to be limited to the immediate subject matter of this survey, but to include other topics, including intangible elements of their cultural heritage. Topics could range from former methods of resource harvesting and management to traditional methods of education, leadership initiation rites and village-based conflict resolution (to name a few).

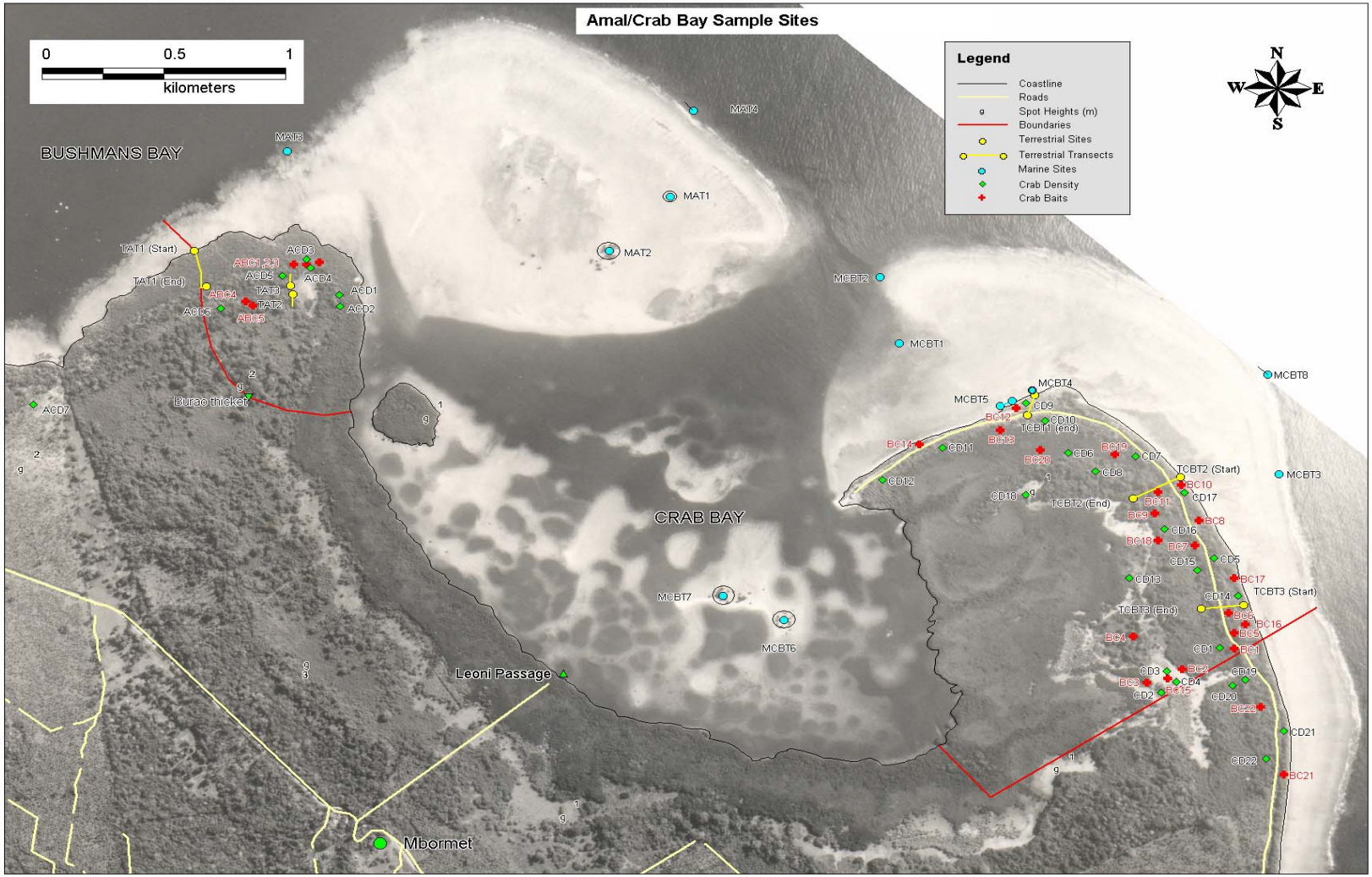

Figure 3: Amal/Crab Bay sample sites

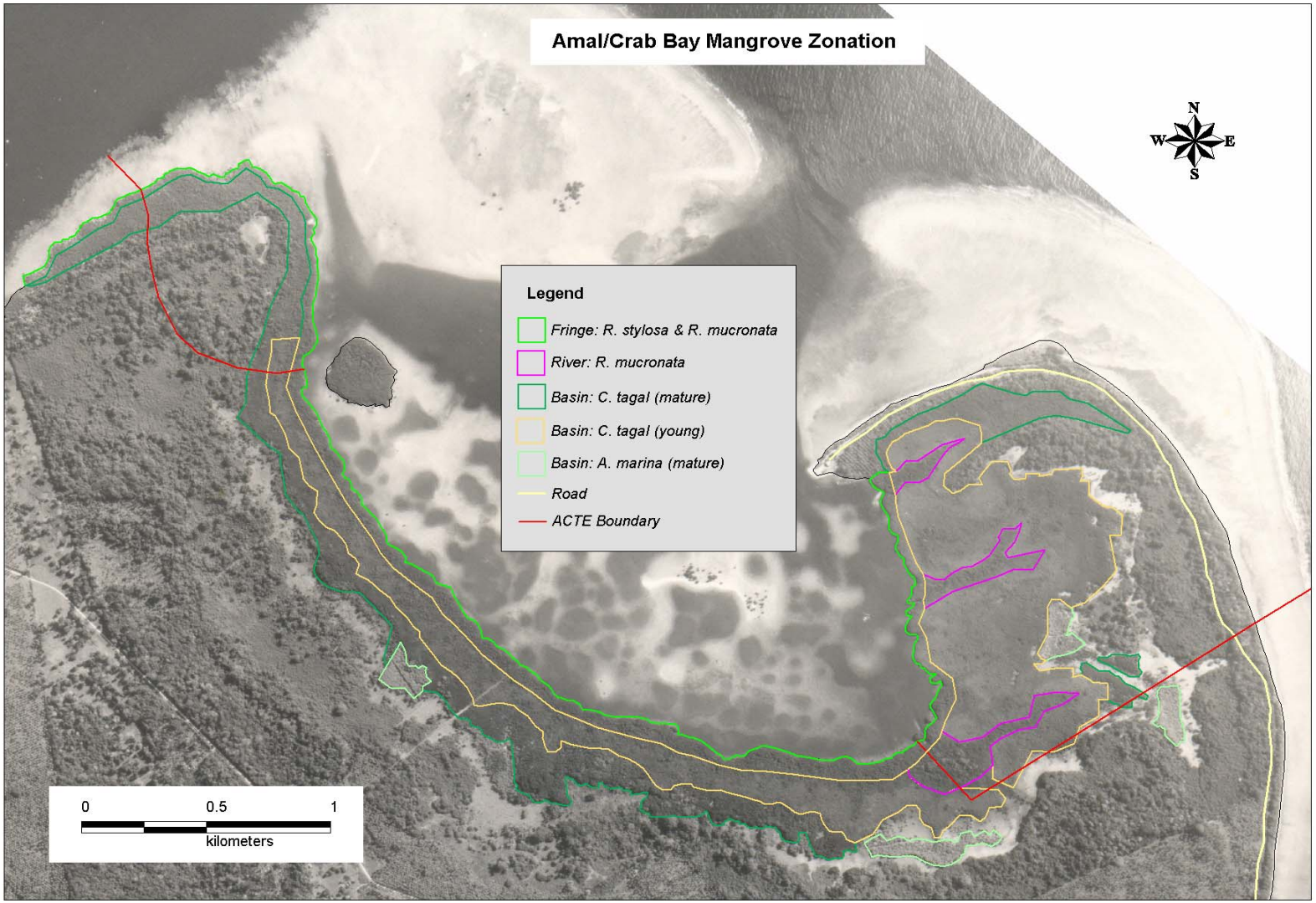

Figure 4: Amal/Crab Bay mangrove zonation

3 Mangroves of Vanuatu

3.1 Overview

The total area of mangrove in Vanuatu is estimated at 2,460 ha (David 1985). The largest area of mangroves found is on Malekula, with a total of 1,915 ha, distributed primarily between two main areas: Crab Bay/Port Stanley in eastern Malekula and the Port Sandwich/Maskelynes Archipelago area in the southeast. Mangroves cover only 1% of Malekula, but this represents 78% of the mangroves found in Vanuatu (David 1985). Other islands with significant mangrove coverage include Hui (with 8.5% of Vanuatu's mangroves), Efate (4%), Emae (3%), and Epi (2.5%) (David 1985).

The southern islands of Vanuatu have very few mangrove areas (one exception is Aniwa; the area is just 15 ha, but this represents nearly 2% of this small island's land mass). Otherwise, mangroves are found only as thickets concentrated at river mouths, inlets or lagoons on various islands of Vanuatu. The lack of extensive mangroves is a result of the predominantly steep nature of the islands and lack of tidal flats and associated coastal lands. The two areas of Malekula cited above, including Crab Bay, are exceptions, having relatively large area of flat, low-lying coastal shelf inundated with tidal waters.

Mangroves have well documented biological and socioeconomic benefits that include the following.

- **Coastline protection** — the complex web of mangrove roots form natural buffers against coastal erosion by reducing the energy of waves, currents and storms.
- **Nutrient production, and sediment and toxicant trapping** — mangroves produce a significant amount of organic matter that in turn provides nutrient enrichment to nearby marine and terrestrial habitats. Mangroves also assist to retain, concentrate and recycle nutrients while removing toxicants through natural filtering processes (sediments with attached toxins are trapped when roots slow waves and currents).
- **Refuge for coastal fauna** — nutrient and plankton rich waters attract fish, prawns, crabs, and seabirds, while fruit bats and birds feed and nest in mangroves; mangroves also support shellfish and protect fish-fry, crab and prawn larvae from predation and wave movement.
- **Raw materials** — mangroves serve as a source of fuelwood, and provide wood and other materials for house and canoe construction and other uses (e.g. for medicine, dyes and cordage).

3.2 Malekula mangroves

Results of surveys by Lal and Esrom (1990) and Esrom and Vanu (1997) confirm that mangroves play an important socioeconomic role in the subsistence and semi-subsistence economy of communities adjacent to extensive mangrove areas. This is particularly so for the offshore island of Uliveo in the Maskelyne Archipelago (off southern Malekula), where mangroves are the primary source of firewood. Lal and Esrom (1990) estimated annual household consumption of mangroves for fuelwood to be 3.6–4.8 t. Esrom and Vanu (1997) estimated that the economic benefits derived from mangal-associated fuelwood, building materials (house-posts and thatch material), crabs and finfish in the Crab Bay/Port Stanley area totaled some 9.5 million vatu (VUV) annually.

In 1971 Marshall and Medway (1976) surveyed the largest concentration of mangals in Vanuatu (at Port Stanley in eastern Malekula, along with other areas of Malekula). The Port Stanley mangals are essentially contiguous with those of Crab Bay, and their structure is very

similar. Like Crab Bay, the Port Stanley area is composed of low-lying uplifted fringing coral reefs, partially inundated with seawater and covered in mangals and lowland coastal forests. They reported that 17 species of "true mangrove tree and mangrove associates", from 10 different families, were present in Vanuatu (though not all of these were found in the Port Stanley area), and noted their zonation patterns (Table 1).

The number of mangroves and mangrove associates recorded by these researchers in Port Stanley totals 13 species from 9 families. Marshall and Medway noted the lack of species diversity relative to that found in Malaysia and northern Melanesia, while confirming their affinity with other parts of the Indo-Pacific. They suggest the relatively low species diversity of mangroves found in the Port Stanley area may be due to:

- the island's volcanic origin and consequent isolation for mangal colonisation (the presence of a gradient of decreasing species diversity from west to east through the Pacific is now well documented for most terrestrial and marine flora and fauna);
- lack of significant freshwater flowing into the bay (this is also true for Crab Bay); and
- shallow soils with little silt deposition.

Table 1: Mangal and associate species found in Vanuatu

Species	Family	Comments	Zone
Acrostichum aureum	Pteridacaea	Swamp fern	A
Heritiera litoralis	Sterculiaceae	Mangrove associate	A
Xylocarpus granatum	Meliaceae	Mangrove associate	A
Derris trifoliate	Leguminosae	Creeper	A
Caesalpinia bonduc	Caesalpiniaceae	Prickly shrub	A
Rhizophora stylosa	Rhizophoraceae	Red mangrove	*D*
R. mucronata	Rhizophoraceae		D
*R. apiculata**	Rhizophoraceae		
*Bruguiera gymnorhiza**	Rhizophoraceae		C
*B. parviflora**	Rhizophoraceae		C
Ceriops tagal	Rhizophoraceae		B
*Lumnitzera littorea**	Combretaceae		
Sonneratia caseolaris	Sonneratiaceae		F
*S. alba**	Sonneratiaceae		F
Avicennia marina	Verbanaceae	White mangrove	E
Clerodendron inerme	Verbanaceae	Shrub	A
Excoecaria agallocha	Euphorbiaceae	Mangrove associate	A

* species identified from areas in Vanuatu other than Port Stanley

3.3 Mangal zonation patterns and functional classifications

In their survey at Port Stanley, Medway and Marshall (1976) followed the mangal zonation patterns developed by Macnae (1968) relating to tidal inundation, freshwater influences and depth and nature of the soil. Categories include: A) Landward fringe; B) *Ceriops* thicket zone; C) *Bruguiera* Zone; D) *Rizophora* Zone; E) Seaward *Avicennia* zone; F) *Sonneratia* zone. They found two of these zones (*Bruguiera* and *Sonneratia*) to be lacking at Port Stanley.

Landward Fringe (A): characterised at its landward edge by *Acacia spirobis, Celtis paniculata*, *Barringtonia sp*., *Cordia subcordata* and *Heritiera littoralis*, while the mangrove associates within this zone (from the seaward edge or mangrove mantle of zone A) included*, Caesalpinia bonduc, Derris trifoliata, Excoecaria agallocha* and *Xylocarpus granatum*.

***Ceriops* zone (B):** well developed and broken down into two sub-zones — a landward zone with no *Ceriops* regeneration beneath it and dominated by *Acrostichum aureum* as groundcover and a contiguous seaward *Ceriops* zone that supported regenerative seedlings beneath it. This sub-zonation is discussed further below under Effects of Tectonic Uplifting.

Bruguiera zone (C): lacking in Port Stanley. Esrom and Vanu (1997), however, note the existence of this species "near the mouth of the Port Stanley River". During the course of this survey the author also identified a lone 8 m *B. gymnorhiza* tree just north of the Uripiv boat landing within the Port Stanley area; it is obviously uncommon in this area.

Rhizophora zone (D): forms a dominant and continuous zone along the sea margin of Port Stanley Bay, interrupted only by sandy spits or creeks. Only at Port Indir did *Ceriops* extend to the sea edge. *R. stylosa* was dominant while *R. mucronata* (a similar but taller species) was never found in aggregations and accounted for less than 5% by area. The existence of *R. apiculata* was never reported.

Avicennia zone (E): the most seaward zone. The only species recorded was *A. marina*, which according to Macnae 1968, exhibits the widest range of salinity tolerance of all mangroves. It was found colonizing the seaward fringe of a lee shore at *Jungin Niviv* (which translate from the Uripiv vernacular as "Avicennia Point"), as well as where creeks entered, and small specimens where found growing on the fringing reef some 70 m from shore. In some areas of complete southeast wind exposure, larger *A. marina* were found closer to shore in association with *R. stylosa* and *S. caseolaris*.

Sonneratia zone (F): not developed into a discrete zone in Port Stanley, with large trees of *S. caseolaris* found sporadically in the *Rhizophora* zone, "notably but not exclusively where creeks emerged, and among *Avicennia* on both mud and coral substrate".

Some researchers de-emphasize the notion of mangrove zonation due to the large number of exceptions and lack of explanations for zonation patterns. An alternative concept is based on a functional classification of mangroves, which includes (the following Ewel et al. 1998) categories.

Fringe mangroves: found along the seaward edge, and receive the brunt of tides and storms and are often exposed to seawater at full strength. They are characterized by prop roots, buttresses and pnuematophores; and are critical to the protection of landward habitats and manmade structures.

Riverine mangroves: found along rivers and creeks and are inundated by both freshwater flows and saltwater tides (i.e. they inhabit brackish areas); they are known to be the most productive due to high nutrient inflows from rivers. They also act as interfaces between rivers and basin mangroves.

Basin mangroves: generally cover large areas behind fringe and riverine mangroves. Being located far inland they are only occasionally entirely inundated by tides. Soil salinity may be very high in areas with high evapotranspiration and limited freshwater influence.

3.4 Vernacular terms

A few vernacular terms for mangroves were collected by Medway and Marshall (1976). These names will be discussed in context of the names collected during the fieldwork for this study.

The notes below highlight the potential difficulties faced in collecting vernacular terms and the importance of asking as many sources as possible, especially amongst older residents who

have retained more vernacular skills, to confirm the nomenclature. It also indicates how the vernacular is being lost and transformed as new names are used or introduced.

Vernacular terms	Equivalent	Comment
Narong (or Rong)	*R. stylosa* and/or mangrove communities in general	This agrees with what we were told regarding mangroves in general; however we understood *R. stylosa* to be termed *Narong neves* (which translates as "Bow mangrove"), indicating its prop roots grow in the form of a bow; one of the traditional uses for the roots is to make bows.)
Rong minmin	*R. mucronata*	This agrees with what we were told, but *Rongminmin* was also given to us for *R. mucronata*.
Rongrat	*Ceriops*	We were informed that *Ceriops* was called *Rongnaim*, but one elderly informant indicated this name was merely a recent descriptive name for its main usage (meaning literally "mangrove post"), and that it was also known as *Rongress* (which translates as "growing straight").
Niviv	*Sonneratia*	*Niviv* was given by a number of sources to indicate *Avicennia*, not *Sonneratia* (which was given as *Namur*). Support for *niviv* indicating *Avicennia* comes, in fact, from Medway and Marshall's observation of a dominant *Avicennia* community at *Jungen Niviv*, referred to in the *Avicennia* Zone E. The local name *Jungen Niviv* (or "Point *Avicennia"* in the Uripiv vernacular) would support this.
Nembardi:	*Acrostichun*	*Nembardi* agrees with the name given to us for *Acrostichun*
Chi	Bay	
Jungen	Point	
So	Reef	

3.5 Mangroves of Amal/Crab Bay

The mangroves of the ACTE were surveyed as part of the terrestrial and marine surveys, and followed the same methodology as outlined for terrestrial flora. This included identifications (in scientific and indigenous terms) in the field as well as taking samples to the Herbarium at the Department of Forestry in Port Vila and to village elders more knowledgeable of vernacular terms.

This list of 14 species found in the present survey (Table 2) agrees with what Medway and Marshall 1976 found for nearby Port Stanley, with the exception that they did not record *X. molucensis* or *R. apiculata*. The positive identification of *R. apiculata* in this survey remains uncertain, however. This also agrees with the list recorded by Esrom and Vanu in 1997 for Port Stanley (with the exception that the latter researchers recorded *B. gymnorhiza* and not *R. apiculata*); they did not record the vernacular terms associated with various mangroves trees and their associates.

Table 2: Crab Bay mangroves and mangrove associates and Uripiv vernacular names

Species	Family	Vernacular term (Uripiv)	Translation & Uses
Rhizophora stylosa	Rhizophoraceae	Narong neves	"Bow Mangrove"
R. mucronata		Narong minmin	"Drinking Mangrove"
R. apiculata?*		Ndrongrat	"Indicator Mangrove"
Ceriops tagal		Narong naim (Rongress)	"Post Mangrove"/Straight Growing Mangrove
Sonneratia caseolaris/alba	Sonneratiaceae	Namur	Not known
Avicennia marina	Verbanaceae	Niviv	"Dislikes other Mangroves"
Excoecaria agallocha	Euphorbiaceae	Natot	
Heritiera littoralis	Sterculiaceae	Nisas	
Xylocarpus granatum	Meliaceae	Noar	Tree similar to 'Nur' (that bears an edible fruit)
X. molucensis		Naelaslas	"Large testicles"=fruit
Acrostichum aureum	Pteridaceae	Nimbiri	
Derris trifoliata	Leguminosae	Natu	"Bitter Vine"

* tentative identification requiring confirmation. A complete list of traditional uses and further explanations of mangrove and mangrove associate's vernacular terms are given in Annex 3 and 4.

3.5.1 Mangrove classification in Crab Bay

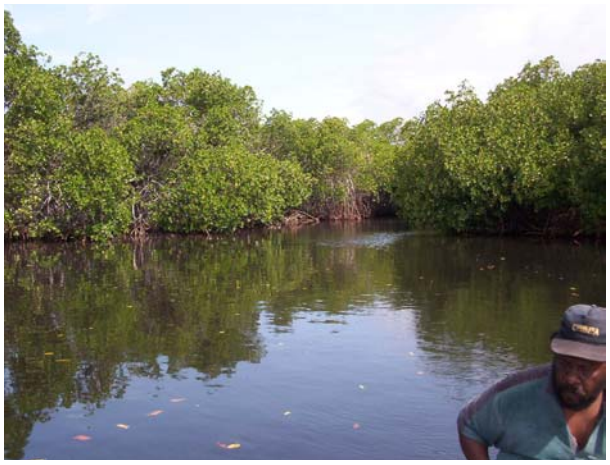

Photo 1: *R. stylosa* is the dominant mangrove found along the entire fringe of Crab Bay creating a rich habitat for fish, shellfish and birds.

The functional classification system described above (see Ewel et al. 1998, among others) is useful in describing the zonation patterns observed in Crab Bay area and is drawn upon in the following description. The zonation observed within the ACTE was generally dominated by large continuous stands of fringe *R. stylosa* found along the seaward margin of the Crab Bay/Amal area. In addition, they were found in monospecific stands far from shore in full strength seawater growing on the Amal fringing reef. *R. mucronata* was found growing interspersed among the large stands of fringing *R. stylosa*, and was found (and often dominated) in areas influenced by freshwater (e.g. in riverine conditions along the small creeks originating in the basin areas of Crab Bay). This characteristic is reflected by the vernacular term for *Rongminmin*, meaning "to drink plenty of water". Young *vicennia marina* was found growing along the seaward fringe on the north of Crab Bay in a large, single, monospecific stand as well as in isolated patches on the Amal fringing reef. The *Avicennia* in both Crab Bay and Amal are of less than 2 m in height, indicating recent colonization, possibly in response to recent tectonic uplifting (see discussion below).

Bruguiera was not present in the ACTE or Amal/Crab Bay. It is generally uncommon in eastern Malekula with the exceptions mentioned above. Despite this, vernacular terms for this genus were given (*Narong jok* in Uripiv, meaning large mangrove; and *Nondong mavis* in Neverver/Limap, meaning a mangrove known from the Vinmavis area of western Malekula).

Photo 2: The mangrove islands (formed by *R. stylosa*) found on the reef flats of Amal (finfish survey site MAT2).

No large discrete *Sonneratia* zone was observed within the ACTE, although *Sonneratia* were abundantly interspersed among other species along the western border of Amal. Some individual *Sonneratia* were also found growing among the *R. stylosa* stands forming small islands within Crab Bay (MCBT6&7) as well as far inland at the fenced western border of Crab Bay. *Sonneratia* was found to be plentiful just outside of the ACTE, alongside the Sarmette River near the estuary. The largest zone of discrete monostands was found growing in the basins of both Crab Bay and Amal, where *Ceriops tagal* dominates. These basins are quite large, extending nearly 1 km from the sea on the western Crab Bay side. The *Ceriops*-dominated basin stands have been impacted by recent tectonic uplifting events, and are consequently broken down into two sub-groups based on the size and age of the trees, which manifests as a different color in the aerial photo summarizing mangrove zonation (Fig 4; this is discussed further below). Additional large monostands of mature and non-regenerative *A. marina* were found in the landward side of the deep mangrove basin on the Crab Bay side, and were also considered to be present as a result of uplift effects.

In summary, the three functional classifications are characterized by the following mangroves within the Amal/Crab Bay area (as summarized in Fig. 4):

Fringe mangroves — primarily *R. stylosa* interspersed with *R. mucronata* and occasional *Sonneratia* spp., and *A. marina*.

Riverine mangroves — dominated by *R. mucronata.*

Basin mangroves — dominated by *C. tagal.* Due to uplifting effects this species was represented by discrete mature and younger stands. The mature stands of *C. tagal* are found along the landward edge while the younger, lighter colored *C. tagal* are found between this sub-zone and the seaward fringe zone; the landward area also has some isolated and large monospecific stands of senescent, non-regenerative *A. marina* located far from their normal fringe habitat due to uplifting.

3.5.2 Effects of tectonic uplifting in the Port Stanley area

Marshal and Medway (1976) noted some unusual mangal zonation patterns in Port Stanley that they attributed to abrupt coastal uplift to which the vegetation has not yet adjusted. An earthquake measuring 7 on the Richter scale occurred in 1965, which resulted in abrupt vertical displacement of .23 m at Lakatoro wharf (now known as Uripiv passage), and 1 m at the outer reef margin. The effects on mangrove zonation include extensive landward stands of *C. tagal* at about High Water Spring (HWS) level, with a dominant groundcover of *A. aureum.* No regenerating seedlings were found beneath them. Some large *A. marina* (normally found close to low water spring — LWS — tidal level) were located further inland. Seaward of the *Ceriops* zone there was an inner zone of non-regenerating *Rhizophora.* This was preceded by a more recently colonized zone of younger *Rhizophora* that established after the uplift event. These

Photo 3: The large monostand of young *A. marina* in finfish sample site MCBT5. The stand presumably has been established since recent uplifting in this area.

observations clearly indicate the effects of abrupt uplifts on mangal zonation in this area of Malekula (Medway and Marshall 1976).

Vanuatu's location at the juxtaposition of the Indo-Australian and Pacific Plate margins (which run parallel to the islands that make up the archipelago) results in continuous tectonic activity, earthquakes and occasional abrupt uplifting events. The movement of the Pacific plate (as it overrides the Indo-Australian plate that underlys Vanuatu) results in a Malekula moving in an east to west direction at a rate of approximately 0.9 mm/yr, while the Austral plate is subducted below it (Douglas Charlie, Department of Geology and Mines, pers. comm.). During earthquakes the release of pressure build-up between these two plates may result in uplifting or subsidence, depending on local fracture zones, with impacts on terrestrial and mangal biodiversity, and fringing coral reefs and seagrass areas (the latter effects are further discussed below).

Photo 4: A stand of mature, non-regenerative *C. tagal* found in the basin area of Crab Bay due to uplifting effects.

Uplift in this part of Malekula is substantiated by local knowledge, which recorded coastal trading vessels anchoring well inside Crab Bay. The area where ships formerly anchored is now far too shallow for them to do so. The local fishers have also noticed that now, during the annual winter low spring tides, it is possible to walk across the reef/seagrass beds from Leoni passage to the Crab Bay headland, whereas formerly this area was too deep to do so.

The effects of uplifting on the Amal side of Crab Bay are also evident with the continuing colonization of this fringing reef with mangroves, primarily *A. marina* and *R. stylosa*. Comparing aerial photos of the area taken in 1986 (Figs. 3 and 4) with mangrove coverage today confirms that mangrove coverage is continuing to increase on the Amal headland relative to 1986. The RFDO, who grew up in this area, also confirms that this is the case. Due to the shallow nature of the bay, however, continued uplifting of this area will be accompanied by continued development of the mangrove community into newly emerged seaward areas. This is apparent in the recent colonisation by relatively young *A. marina* of a large area along the beach on the north face of Crab Bay Point at MCBT5 (Photo 3).

The large landward area of monospecific stands of *Ceriops tagal* on the Crab Bay side (found along the southern border fence, west of the entrance gate; see Fig. 4) were observed to lack regenerative seedlings beneath them, indicating this area has been uplifted beyond the

Photo 5: The Amal "desert" area of hyper-saline soil during the winter months and seasonal low tides.'

Photo 6: The Amal "desert" inundated with seawater during the summer months when the tides are at their annual high.

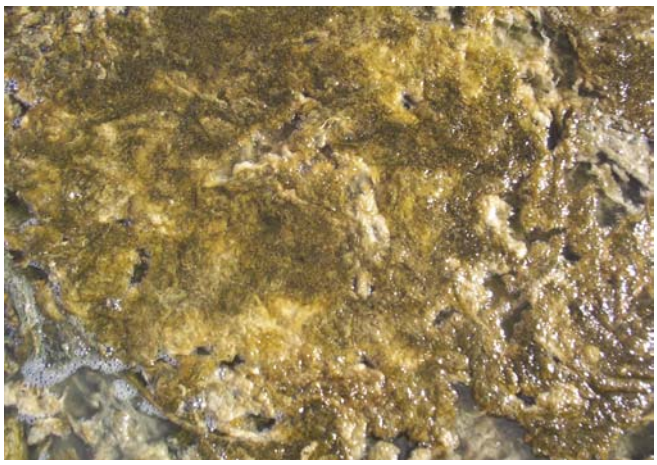

Photo 7: A close-up of the algal bloom covering the Amal "desert" area observed during summer inundation.

maximum height above sea level at which sustained regeneration can occur. This area is characterized by a stand of *C. tagal* of uniform size that is gradually dying and not being replaced through recruitment (Photo 4). This is occurring along the edge of a fairly extensive hyper-saline mudflat devoid of any flora and locally termed a "desert".

The uplifting and resultant vertical movement of mangroves above their regenerative tolerance limits, leading to the gradual dying off of mangals, indicates a succession to lowland forest habitat. The residual hyper-salinities of these soils, replenished during summer high tides, inhibits the colonization of these areas by terrestrial flora. These "desert" areas appear result from a combination of uplifting, seasonal saltwater inundation and lack of significant freshwater input, and represent the transitional phase between mangrove and landward zones. The desert area of Amal can be clearly seen in Photo 5.

As observed during field work, the maintenance of these deserts is supported by annual inundation of these areas during summer tides (that coincide with the rainy season) (photo 6). The resulting water temperature of the pooled water over these open areas reaches temperatures estimated to be over 40^0C. High water evaporation would be apparent in such areas, thereby leaving residual hyper-saline soils. Blooms of algae floating on the surface waters (photo 7) cover the entire flooded area during the summer season.

Presumably as a result of these extreme conditions (prolonged exposure to high temperature seawater), the groundcover of *A. aureum* and *Derris* foliage was observed to have died off during the period of inundation observed in late January. Fiddler crabs observed in high density in these deserts during the pre-wet season had reportedly migrated to higher ground. One also wonders what the toxicity effects of "cooking" the *Derris* vines (used locally as a fish poison) in a hot broth would have on the flora and fauna? However, the RFDO reported seeing small unidentified

fish swimming beneath the surface algal layer in these waters in early February 2005, so at least some species are tolerant of these extreme conditions.

Photo 8: The shrinking "desert" strip between encroaching terrestrial vegetation and the mangrove basin.

When visiting this area in May 2005, the tides no longer fully inundated the area and the large *Derris* vines were starting to shoot new foliage again. The fiddler crabs had yet to recolonize this area.

On the Crab Bay side of the ACTE, uplift effects have created a unique habitat in the inner basin area of mature *C. tagal*, including non-regenerative areas along with similar areas of *A. marina*. These areas are clearly visible in the aerial photo indicating mangrove zonation as large non-vegetated hyper-saline "desert areas" (Fig. 4) This area was formerly accessible by a lane off the main access road into Crab Bay and used for teaching people to drive cars, as it is a large flat area with little to run into.

Local informants indicate that the coastal vegetation has colonized areas of the landward fringe since the aerial photo was taken in1986. The hyper-saline desert strip between the mangrove basin and coastal forest is thus smaller today (see Photo 8) than in Fig. 4. The main species encroaching into this area include *Derris trifoliata, Pandanus tectorius, Acacia spirobis, Acrostichum, Ficus* sp*., Premna corymbosa and Glochidion* sp. As the narrow non-vegetated strip is easy to walk through, this remarkably unique and aesthetically pleasing environment inhabited by crabs, swamp harriers and other birds as well as flying foxes is easily accessible. The ACTE MC may consider cleaning the access lane (although not enough for vehicles) to allow easier walking access for tourists to enjoy this unique habitat created by tectonic uplifting so as to include it on interpretive tours to the area.

3.5.3 Complimentary management measures in Crab Bay area

The community of Uri Island initiated an MPA in 1992. Termed "Narong Park", this area covers 70 ha of mangrove resources and 130 ha of coral reefs, mudflats, seagrass beds, sand spits, sand cays and lagoons (Esrom and Vanu 1997). The area straddles the Port Stanley peninsula, including (i) a marine area inside the bay where *Tridacna* breeding circles have been established, (ii) the mangals of the peninsula, and (iii) a fringing reef on the windward side of the peninsula just south of Uri Island. This area is closed to all fishing and hunting activities and these restrictions are said to be well respected. The mangrove oysters are occasionally harvested, however, as they have become very abundant. As they are observed to live less than three years, it is felt that this resource is going to waste, and should be utilized (Chief Predrick, Uri village, pers. comm.).The closed area is managed entirely by the relatively small community (relative to the fishing grounds available to them) of Uri and the tenure of the area is undisputed. The existence of this proactive management measure reflects the relative dependence of the Uri community on marine and mangal resources, and has succeeded in part because Uri is a small community with strong leadership. The socioeconomic benefits of the mangrove resources of the Port Stanley area are well documented (see Esrom and Vanu 1997).

The mangroves have been found to be colonizing the open area between the reserve and Uri Island and this is perceived to reduce tidal flushing of this embayment. For this reason, the village leader has allowed the clearing of young mangroves found colonizing the gap in order

to maintain tidal flushing and good water quality (Chief Predrick, pers. comm.).

The colonization of this gap may be caused by tectonic uplifting in this area. The expansion of mangroves over reef flats is also observed in the Maskelyne Islands area of southern Malekula and the loss of reef fishing areas had prompted the Maskelyne Islanders to invite loggers to clear these mangroves in the early 1990s (Kevin Mores, pers. comm.). This plan was thwarted by the intervention of the Environment Unit on the grounds of protecting fisheries habitat. The transition of reef flats to mangrove areas around Malekula is no doubt aided by the ongoing uplifting of this area in response to tectonic forces.

4 Avifauna of Crab Bay

A total of 121 species of birds are recorded from Vanuatu, of which 32 species are widely ranging seabirds, 15 species are shorebirds and 74 are land and freshwater birds (Bregulla 1992). Most species are widely distributed and are found throughout the archipelago and in most habitats. The relatively low number of species present means that they encounter less competition and are thus more likely to inhabit a wider range of niches than if more species were present. There are nine endemic species and one endemic genus. The low degree of endemism is attributed to repeated immigration, high extinction rates, and the fact that few bird populations remain separate over a sufficient period to evolve into distinct endemic forms (Diamond and Marshall 1977).

Only 12 species are known to have a restricted distribution. Four species are restricted to lowland or montane forests and have differentiated into distinct races or species. Seven are confined to wetland habitats (including mangroves, swamps, freshwater, etc.), and these show no differentiation into species or sub-species. These species live only where these habitats are found and are particularly vulnerable to extirpation (Diamond and Marshall 1977). The species most likely to be found in Vanuatu's wetlands include the following (Donna Kalfatak, Vanuatu Environment Unit, pers.comm.).

Herons: The eastern reef heron (*Ardea sacra*) favours rocky coasts and reefs, sea cliffs, mangroves and mudflats. It may also be found along river estuaries and creeks, and was also observed several times by Medway and Marshall (1976) up to 12 km inland along Apuna River on Santo. The little mangrove heron (*Butorides striatus solomonensis*) is the smallest of the herons found in Vanuatu. Length is about 40 cm. Coastal mangroves are favorite habitats and this heron is also sometimes observed on mudflats at low tide, and along marshy creeks, river banks and other swampy areas.

Waterfowl (ducks): The mallard (*Anas platyrhynchos*), found in still water, freshwater lakes and ponds, sheltered coastal bays and estuaries. Single record on Tanna (Middle Bush). The Pacific black duck (*Anas superciliosa pelewensis*; other common names are the Australian grey duck or black duck) is the best known and most commonly seen duck in Vanuatu, found in swamps, rivers, lakes, creeks, mangroves, estuaries and even the mountains and outer reefs. The grey teal (*Anas gracilis*) is also recorded as being present.

Harriers: Swamp harriers (*Cirus approximans*) are active hunters and forage on marshes, lakes, grasslands and plantations.

Swamphen: The purple swamphen (*Porphyrio porphyrio samoensis*) is commonly found close to permanent water bodies, swamps, rivers and lakes, where reeds and other riparian vegetation provide hiding areas and nesting habitat.

Crakes: The spotless crake (*Porzana tabuensis tabuensis*; also known as the sooty rail) is the smallest of the rails in Vanuatu. It is found in coastal areas, especially large swamps, lakes, and marshy grasslands near water, and sometimes in salt-marshes and mangroves.

Marshall and Medway (1976) noted the avifauna observed during their survey in nearby Port Stanley in September/October 1971. Their observations of avifauna from the mangles and

adjacent broad leaf lowland forest or adjacent plantations, which included sampling using mist nets, are summarized below (Table 3), with feeding habit comments from Bregulla (1992).

Table 3: Avifauna in the Port Stanley area, Central Malekula

Scientific name	English/Bislama	Observation/comments
Species in mangal and mangal associates		
Egretta sacra	reef heron	roosts in mangroves (*Rhizophora*)
Butorides striatus	little (mangrove) heron	feeds on fish, crabs, prawns, insects, etc.
Circus aeruginosus	swamp harrier	feeds on rats, mice and other birds & fowl
Rallus philippensis	rail/nambilak	eats insects, worms, snails, lizards; semi-nocturnal
Pluvialis dominica	Pacific golden plover	eats crabs, shrimps, snails, etc; migratory
Numenius phaeopus	whimbrel	feeds on mudflat; roosts in mangal (*Ceriops*)
Heteroscelis incanus	wandering tattler	roosts on lower branches
Sterna bergii	tern	floating on a log in channel
Ptilinopus greyii	red bellied fruit dove	amongst *Ceriops*
Chalcophaps indica	green winged ground dove	throughout mangal
Halcyon chloris	kingfisher	throughout mangal
Hirundo tahitica		flight overhead
Lalage leucopyga		*Ceriops* zone
Coracina caledonica		*Ceriops* zone
Gerygone flavolateralis		throughout mangal
Rhipidura spilodera		*Ceriops* zone
Myiagra caledonica		throughout mangal
Artamus leucorhynchus	white-breasted woodswallow	flight overhead
Phylidonyris notabilis		landward fringe
Lichmera incana		throughout mangal
Zosterops lateralis	grey-backed whiteye	common throughout al zones of the mangal
Species noted in adjacent lowland coastal forest or old plantations		
Gallus gallus	wild fowl	
Ducula pacifica	Pacific imperial pigeon	
Columba vitiensis	white throated pigeon	
Macropygia mackinlayi	pheasant dove	
Trichoglossus haematodus	lorikeet	
Collocalia esculenta		
Halcyon farquhari *	kingfisher	
Turdus poliocephalus		
Neolalage banksiana		
Pachycephala pectoralis		
Myzomela cardinalis		
Zosterops flavifrons *	Vanuatu (yellow) whiteye	

* species endemic to Vanuatu. Source: Marshall and Medway 1976; feeding habit comments from Bregulla 1992.

These researchers used a standard 4 ha mist-net grid set in the *Rhizophora* zone and in both *Ceriops* zones to sample the birds associated with the mangals of Port Stanley. In a total of 96 hours of mist-netting, 26 birds representing eight species were caught. They conclude that while the diversity of netted birds was comparable to mist-net catches in terrestrial habitats on Malekula and elsewhere in the archipelago, both the number of birds caught and the total

number of species recorded in the netting area were by comparison much lower.

Table 4: Avifauna known to reside in the Crab Bay area, including the reefs, mangroves, lowland forests and adjacent plantations

Scientific Name	English	Common Name /Bislama
Acipiter fasciatus	brown (australian) goshawk	
Anas superciliosa	Pacific black duck	wael dak o dakdak
Ardea sacra	eastern reef heron	
Artamus leucorhynchus	white-breasted woodswallow	
Butorides striatus	little (mangrove) heron	swamp red hed
Chalcophaps indica	green-winged ground dove	sotleg
Circus approximans	swamp harrier;	hawk (bigfala)
Collocalia esculenta	swiftlet	white bellied swiflet
Columba vitiensis	white-throated pigeon	nataro
Dacula pacifica **	pacific imperial pigeon	nawimba
Ducula bakeri *	vanuatu mountain pigeon	big head
Esacus magnirostris	beach thick-knee; shorebird	
Fregata spp.	frigate bird	pidjin blong hariken
Gallirallus philippensis	rail	nambilak
Gallus gallus	red jungle fowl	wael faol
Halcyon chloris	king fisher (white chest)	waet nasiko
*Halcyon farquhari**	king fisher (brown chest)	nasiko (braon)
Heteroscelus incanus	wandering tatler	
Lichmera incana	silver eared honeyeater	kuskus (small)
Macropygia mackinlayi	rufous brown pheasant dove	longtel
*Megapodius freycinet layardi** **	megapode, scrub duck	namalau
Myzomela cardinalis	cardinal honeyeater	redhed
Neolalage banksiana	vanuatu (buff-bellied) flycatcher	champion (short mouth)
Numenius phaeopus	whimbrel	whimbrel
Phylidonyris notabalis *	vanuatu mountain honeyeater	kuskus big (10 tongue)
Porphyrio prophyrio	purple swamphen	swamp red hed
Ptilinopus greyii	red bellied dove	grin pidgin
Ptilinopus tannensis *	vanuatu fruit dove	bigfala grin pidgin
Rhipidura spilodera	spotted fantail	champion bird
*Trichoglossus haematodus**	rainbow lorikeet	nasiviru
Tyto alba	barn owl	naet hawk
*Zosterops flavifrons**	vanuatu (yellow) white eye	yelo nalaklak (waet eye)
Zosterops lateralis	grey-backed whiteye	waet eye

* endemic to Vanuatu; ** regarded as locally vulnerable due to subsistence pressure. Source: IWP CFs.

The avifauna list in Table 4 was originally prepared in Bislama, and later supplemented with the vernacular terms for the three indigenous languages used in the area (Hatbol, Neverver and Uripiv). The vernacular terms for the Aves are given in Annex 5. Birds of Vanuatu (Bregulla 1992) was used to assign the scientific names. As not all the birds from this reference list the Bislama name, cross-referencing to the vernacular was not always possible.

A number of CFs commented on the importance of mangroves and adjacent lowland forests to avifauna for feeding, nesting and resting. A number of local people commented on the increase in numbers and lack of wariness of the red jungle fowl (*Gallus gallus*) in Crab Bay. Although this survey did not concentrate on the avifauna of this area, some anecdotal nesting observations were made. In late December 2004, the nest of a red bellied fruit dove (*Ptilinopus greyii*) was observed in the bushes of Amal in the vicinity of TAT3. In February 2005 three separate reef heron (*Ardea sacra)* nests were observed among the prop roots of the *Rhizophora stylosa* "islets" found on the Amal fringe reefs (MAT2), including one with a hatchling (Photo 9).

Photo 9: Reef heron nest found in the mangrove islands of Amal (MAT2) with newly hatched chick.

It was also reported by the CFs that the black headed mannikin (*Lonchura malacca*) had been introduced to Malekula in the 1980s from another island, possibly Santo. It is now commonly seen in the plantations of central Malekula, where it reportedly preys on birds eggs.

5 Mammals of Crab Bay

Marshall and Medway (1976) documented the existence of the frugivorous flying foxes *Pteropus tonganus* and *P. aneitianus* in the mangles of nearby Port Stanley. They also noted the existence of colonies of two species of insectivorous microchiropteran bats residing in nearby caves at Litslitz, and suggested they may feed in the mangals. They set rat traps on a sandy spit but these yielded only one specimen of rat (*Rattus exulans*), the remaining traps being sprung, presumably by crabs.

Esrom and Vanu (1997: 14) noted that three flying fox species (big black-flying fox, *Pteropus tonganus*; small black-flying fox, *Pteropus fundatus*; and white-flying fox, *P. aneitianus*) were common and maintained large and healthy colonies. While *P. tonganus* is widely distributed in the Pacific east of the Cook Islands, the latter two species are endemic to Vanuatu. *P aneitianus* is found throughout most of the archipelago, whereas distribution of *P. fundatus* is believed to be restricted exclusively to the Banks Islands (to date literature records for this species are exclusively from Mota and Vanua Lava islands; see Helgen 2005).

While mammals were not a focus of this Survey, the CFs provided a list of mammals known to reside in the Amal/Crab Bay area. They are considered here due to the subsistence pressure on flying foxes, as well as the impact of introduced mammals in the AKTE.

A list of mammals known to reside in or be present on occasion in the AKTE, as well as their reported prey items, is presented in Table 5 (vernacular terms are given in Annex 6).

Table 5. List of mammals known to reside in and around the ACTE.

Common Name	Species	Reported Prey Items
feral dog	*Canis* sp.	birds & eggs; turtle hatchlings; fruit
feral cat	*Felis* sp.	birds & hatchlings; rats, mice
feral pig	*Sus* spp.	crab, roots for grubs, worms, fruit
mice	*Mus* spp.	
rat	Rattus spp.	Birds & eggs; turtle hatchlings?
black flying fox	*Pteropus tonganus*	Fruits
white flying fox	*Pteropus anetianus* *	Fruits
small bat (with tail)	*Notopteris macdonaldi* **?	eats bird eggs
Mangrove Flying Fox	*Pteropus fundatus** or juvenile *P. tonganus*?	Nectiverous including on mangrove flowers

* endemic to Vanuatu; ** endemic to Vanuatu and Fiji. Source: IWP NCs.

Introduced species of mammals, including dogs, cats, mice, pigs and rats[3] are all found in their feral state in this area. As can be seen by the above list, their prey items include wild birds, their eggs and hatchlings, as well as lizards, insects, turtle hatchlings and crabs. Although there is no data on the impact of these introduced species to the indigenous species of birds, crabs and turtles, there may be some value in examining this issue to determine the viability of introducing an eradication effort of these feral mammals within the AKTE.

Two other bats are interesting and anomalous from this list. The "mangrove flying fox" (translated from the vernacular) is said to be a small black flying fox that is found in large groups in the mangroves. It is particularly found in *Ceriops tagal* stands during the wet season when all species of flying foxes are plentiful in the coastal areas and found feeding on ripening fruit.

The mangrove flying fox is reported to feed on the nectar and flowers of the mangroves. It is tentatively identified as *P. fundatus* which is, as stated above, known only from two islands in the Banks group and thus has one of the smallest geographic ranges of all flying fox species worldwide (Helgen 2005). This species should be collected and examined by an appropriate mammal expert for identification. If it is in fact *P. fundatus*, then this find is significant in that it extends its known range to central Vanuatu. Due to limited knowledge and the unique status of this endemic species, Helgen (2005) recommends the additional study of its conservation status and basic biology. It should be noted that some informants suggested that this species may be juvenile *P.tonganus* — and if this proves to be the case, the importance of mangals to this species will be highlighted. As flying foxes in Vanuatu are found to bear young from October to December (RFDO pers comm.), it is possible that they feed in remote mangal basins during their juvenile phase. Further study of this bat is warranted.

The other interesting bat in this list is the "small bat with tail" said to eat birds eggs. The two candidate species for this bat are the insectivorous Pacific free tailed bat (*Chaerephon bregullae*) or more likely, the nectarivorous Pacific blossom bat (*Notopterus macdonaldi*), which is endemic to Fiji and Vanuatu. The latter is a unique bat with a long tongue and is important in cross pollinating flowers that it feeds on. Although neither of these bats is known to eat bird eggs it is more likely that the latter may do so (Helgen, pers. comm.). This species of small bat with tail should also be investigated further for positive identification and broadening of documented ecological knowledge.

[3] Pigs and rats were introduced by the earliest Pacific colonists some 3,000 years ago along with later introductions of European origin.

The former species (*C. bregullae*) is also endemic to Fiji and Vanuatu and records are only known from Santo, Malo and Aore islands in Vanuatu, and Vanua Levu and Taveuni in Fiji. If this bat is found to be *C. bregullae*, this would also increase its known distribution.

The marine mammal (*Dugong dugon*) is covered in a later section.

6 Crabs of Crab Bay

6.1 Land crab biology

Lal and Esrom (1990) report three species of *Cardisoma* found in Vanuatu. The main species of crab utilized for both subsistence and commercial purposes in Crab Bay is the white land crab *Cardisoma carnifex. (Cardisoma: Cardi=heart; soma= body.)* This species' geographical range extends from the Red Sea to Natal, Aldabra, Anadamans, Japan, Taiwan, Celebes (Sulawesi) and Polynesia (Gillikin and Verheyden 2001). The second most common species is the black crab, *C. hirtipes.* These are brachyuran (infraorder) crabs of the family Gecarcinidae, or terrestrial crabs that have adapted to living on land. The primary adaptation is that the two cavities under either side of their carapace containing their gills are enlarged and modified to support respiration. Their gills must remain moist to function properly, however, and this is accomplished by burrowing into the water table. All terrestrial crabs are burrowers, are primarily nocturnal, and all have a marine larval stage.

6.1.1 Reproductive biology

Larval development takes place in the sea and indirectly passes through a series of five zoeal stages lasting 22–25 days (in vitro) followed by a postlarval megalops (Kunnupandi et al. 1980). In Kenya, the omnivorous *C. carnifex* crab has been found from stomach content analysis to primarily consume the mangrove *Avicennia marina* leaves.

During the reproductive period for land crabs, (timed to coincide with the wet season) courting males, ovulating and berried females move to the zone closest to the sea. Courting behavior is generally restricted to daylight hours. Copulation occurs with the male and female facing each other ventrally. The first pair of pleopods of the male conducts sperm to the seminal receptacles located under the abdominal pouch of the female. Sperm is then used to internally fertilize the ripened eggs of the female. Egg release will take place some time later when females enter the sea to shake the eggs free as they are washed by the waves (Barnes 1980).

There is only limited ecological or reproductive information published specific to *Cardisoma* crabs for the Pacific area. However, some relevant reproductive observations were made for two sites on Lizard Island (14^0 $40^{"}$ S, 145^0 27" E) on the Great Barrier Reef (GBR) in a study between 1987 to 1990 (Quinn et al. 1991). The first site — at Watson‘s Bay — consisted of two areas of approximately 400 m^2, containing over 300 active burrows. The second site — at Mermaid Cove — comprised 300 m^2 and 200 burrows. Burrow densities ranged from 0.67 to 0.75 burrows/ m^2 among the two sites. The burrows were at a grassy mangrove edge above the high water mark.

Female crabs were observed migrating from their burrows to the ocean, where they swam to a maximum of 15 m from the shore to depths of 0.1–3.0 m in order to release their larvae. Hatching was induced when the egg-laden abdomen was flicked by the female, rupturing the egg cases and releasing the zoeal larvae. Each 300–400-gm crab released 350,000–450,000 eggs, the egg mass being related to body weight. This study also revealed that spawning was highly seasonal and tied to lunar phases. Spawning was observed in October, December and January. Groups of mainly 10–30 crabs, but as many as 70, were observed to spawn about three nights before a new or full moon during these months. On one occasion, 50 crabs spawned on the new moon.

No males were observed during any of the migrations. It was determined that sight played an

important part in orientation during spawning migrations and that migrating crabs would stop if a light or large shadow were near them. By tagging a sample of spawning females, it was observed that none of the tagged females were captured during subsequent migrations, indicating that individuals may only spawn once per season.

A total of nine copulations were observed, six between October and January and two during the last week of May. It was inferred that copulation occurs 1–5 months prior to spawning; it was noted that under unfavorable conditions, *Scylla serrata* may spawn up to 7 months after copulation. Copulation occurred during the intermoult period near the female burrow. The male did not restrain the female, there was little motion during the event, nor were any other males nearby. Copulation ceased within 1–10 minutes of being observed, and the female returned to her burrow while the male slowly moved away (Quinn et al. 1991).

In southern India, at 11^0 N, berried females of *C. carnifex* were found throughout the year, but had two distinct spawning peaks (Narayanan et al. 1988). The peaks occurred in April (summer) and September (pre-monsoons) with very low reproductive activity found during the wettest months of the monsoons. The authors indicated that salinity was a dominant factor influencing the reproduction of coastal and estuarine organisms and correlated the two reproductive peaks found with periods of high seawater salinity and rich plankton growth. Thus, the two reproductive peaks occurred when there was an abundance of plankton available for nourishing crab larvae. They also cite a number of other researchers that have found that salinity levels influence ovarian, embryonic and larval development.

Adamczewska et al. (2001) researched the endemic brachyuran land crab *Gecarcoidea natalis* of Christmas Island using radio-tracking, mark-recapture and counting methods. These crabs were enumerated in large quadrants just after dawn when foraging activity was high or during overcast conditions when similar foraging levels were noted. They found crabs in densities ranging from 0.09 to 0.57 crabs/m^2. The largest males were found on the highest plateau farthest from shore. During the dry season, crabs remained inactive but immediately began their migration to the coast with the coming of the rains. In years with early rains, migrations began earlier, which allowed the crabs to take more time feeding along the way. In years when the rains arrived later, migrations were noted to be rushed because while migration is initiated by the onset of the rainy season, actual spawning activity is synchronized with lunar phase. Spawning occurred 17–18 days after mating (Adamczewska et al. 2001).

During spawning migrations, crabs are most active during the first few hours of the early morning as well as in the late afternoon. Males excavate burrows and mating occurs in or near the burrows. Males then return to inland areas while females remain in the burrows for another two weeks until incubation is complete. They then emerge to travel to the coastal cliffs and release their eggs into the sea after which they then return to the inland areas while the larvae spend 3–4 weeks at sea before returning to land as juveniles. The synchronization of spawning activities is considered important in maximizing survival of crab larvae.

Most crabs migrate to specific locations on the island (northwest side), even though it is not the closest coastal site for them (i.e. they have specific locales for spawning). Migration paths did not follow island contours, but were found to follow remarkably straight lines. There was no migratory activity at night. Migratory navigation methods are not well understood but are considered to potentially involve visual cues, polarized light, magneto reception and learning (Adamczewska et al. 2001).

Goshima et al. (1978) conducted a radio-telemetry study of *C. hirtipes* in the Ryukyu Islands, Okinawa Prefecture, Japan, during the non-breeding season. Two types of movement were documented: localized (during dry periods) when the crabs did not move far but did not always use the same burrow, and longer distances (during wet periods) when crabs moved to new foraging grounds and also made use of different burrows. *C. hirtipes* were found to inhabit the bush and grasslands near the seashore, and were sometimes found a few kilometres inland with burrow densities ranging from 0.15 to 0.23 /m^2. Only ovigerous females migrate to the sea to

release zoea around the time of the highest high water during breeding season.

6.1.2 Ecology and foraging

Energy flow in mangroves depends on production of large amounts of organic matter such as leaf litter, which forms the basis of a complex food web. *Cardisoma* crabs form an important link in these systems, as aside from forming an important link between primary producers and consumers, they also prevent the loss of nutrients from mangroves by recycling production within the system. Removal of a large number of crabs can therefore seriously impact ecosystem function within the area (Pederson et al. 2003).

The foraging activity pattern of *C. hirtipes* in southern Japan during the non-breeding season was found to be primarily nocturnal. No crabs were ever observed during daytime, except on rainy days. After sunset however, crab activity began and reached a maximum between 0200 h and 0400 h. Activity then decreased sharply towards dawn and stopped just prior to sunrise at 0600 h. On rainy days, activity would commence around 1600 h, about three hours before sunset. The average number of hours of activity per day was only 2.2 hours. Their activity was restricted to times of relatively low rates of evaporation (i.e. at night and/or times of rainfall; Goshima et al. 1978).

Although crabs had only short activity times within a 24-hr period (i.e. 2.2 hours/day), they were frequently seen returning to their burrows with leaf material, so it was inferred that they continue to feed on this material once in their burrows. The presence of decaying leaf material in *C. carnifex* burrows would also support this inference (Hogue and Bright 1971).

6.2 Traditional knowledge of land crabs in Crab Bay

6.2.1 White crabs (*nevri sal* in Uripiv language; *nevri*=crab; *sal*=float or swim)

According to traditional knowledge from Crab Bay, *C. carnifex* crabs reside year round along the coastal strip, burrowing and feeding in plantations, lowland forests and mangrove mantles. Being so close to the sea along the coastal strip means their burrows easily extend to the water table. They are also found feeding within the mangroves when these are exposed at low tide. Those found far in the mangroves climb trees to avoid immersion when the tide returns and may conceal themselves in hollow stumps.

The crabs living in nearby plantations feed on the grasses and leaf litter, as well as on cow dung, and typically daytime foraging occurs immediately after a rain. Crabs in the lowland forests feed on live and decaying leaves and other detritus, and are thought to also eat other dead crabs (as observed when a truck inadvertently runs one over). The crabs foraging among mangroves consume leaves as well as mangrove prop root tips and mangrove fruits. During periods of heavy rains when burrows become flooded for extended periods, crabs emerge to seek higher ground. These periods are ideal for crab harvesting.

Although no stomach content analysis was done, it is apparent that their diet does not rely heavily on *A. marina*, as observed in Kenya (Kannupandi et al. 1980). This is apparent due to the relative paucity of this mangrove species in Crab Bay, even though there is an abundance of crabs. Within Crab Bay, where they have been protected for the last three years, the crabs feed diurnally as well as nocturnally. However, during prolonged dry periods, especially in the heat of the day, they spend most of the day in their burrows, where they remain cool and moist near the water table. They become very active late in the afternoon, and again towards sunrise.

During the winter months they are known to moult in their lowland burrows, which they conceal from the inside by plugging the entrance with earth. However, intermoult crabs are still found foraging in the Crab Bay area during winter months, primarily during periods of rain as well as from late afternoon to early morning when evaporation is reduced. Foraging also occurs in the extensive mangroves, as this habitat remains moist from tidal inundation year round.

Spawning events by female *C. carnifex* in the Crab Bay area are said to occur in small groups, as was found at Lizard Island. The crabs primarily spawn from November through February (this may vary with rainfall over different years). The fact that the copulation of crabs at Crab Bay has rarely been observed implies that most mating occurs in burrows.

6.2.2 Black crabs (*Nevri namut* in Uripiv language; *mut*=black)

The following ecological notes on the black crab of the Crab Bay area are synthesized from the TK of the area supplemented with direct observations by the author. The black crab (*C. hirtipes*) is normally found slightly farther inland of the coastal forests throughout most of the year (where they also presumably burrow to the water table) and hence, are often found close to rivers and streams. Both males and females migrate to the seaward margin of the coastal strip during summer months, and are reported by local residents to become plentiful near the sea starting in about January. The crabs thus appear to have their spawning season staggered slightly behind that of the white crab. Their prevalence in the Lakatoro market after the New Year compared with late November/early December (an indication of their increased abundance near the coast), was also apparent.

Males and females are said to inhabit the same burrow and copulate within the burrow. They are both said to emerge when the eggs have ripened and are ready to be released into the sea. A spawning migration of *C. hirtipes* was witnessed by a crab collector (Lekolan of Port Indir) at Bushman's Bay on 23 January 2005, at sunset, and again the next morning on the 24th at sunrise. This coincided with just prior to a full moon, which occurred on the 25th. This spawning event was said to have included a much larger number of crabs relative to the small groups of white crabs previously observed by this crab collector to spawn.

Lunar periodicity for crab spawning in Crab Bay is thus confirmed. Because these crabs spawn during the highest spring tides of the year, their larval export is maximized due to the strongest yearly exhalent (ebb-tide) currents. Johannes (1981) notes the importance of *Cardisoma* spawning at full moon spring tides in Palau to ensure larval export away from nearshore reefs in order to reduce high predation rates found there. He postulated that full moons were preferred to new moons because moonlight was useful for navigating to spawning beaches.

The black crabs finish spawning by the end of February and begin migrating to their inland winter habitat, where they remain and also moult during winter months.

6.2.3 Juvenile crabs

The fishers of Crab Bay say that they rarely see the small juvenile land crabs. Researchers in Kenya (Vanini et al. 2003) had also never seen one less that 5-cm in 12 years of researching crabs in Kenya (where a 5-cm crab is three years old). By pouring wet cement in adult crab burrows, these researchers discovered that juveniles remained in conspecific crab burrows for at least three years feeding on excess leaf litter introduced to the burrow by the adult crab inhabiting it. Juveniles inhabit smaller diverticula off the main burrow and remain in these moist burrows that extend to the water table until their transformation into adults. This gradual transformation is accompanied by an inflation of their brachial region during which there is an increase in thickness, vascularisation and surface area of the land crab's "lung" (Vanini et al. 2003). These researchers hypothesize that only after this transformation are crabs able to leave their moist burrows to forage for themselves as adults.

This research potentially resolves the issue of where juvenile crabs reside but also raises the question of whether the land crabs of Vanuatu have similar growth rates. If it takes three years for a crab to complete their juvenile phase to 5-cm, then the time necessary for crabs to reach sexual maturity — and thus for stocks to increase — is considerably longer than originally presumed. These questions highlight the need for more research into land crab growth rates and size at sexual maturity in Vanuatu in order to resolve these questions and provide a stronger foundation for management decisions.

Intrigued by the question of where juvenile *Cardisoma* crabs reside, the author of this report undertook some "backyard research" on the island of Efate where he resides in Erakor Lagoon (Hickey and Vatu, unpublished data). There is a high density of *C. carniflex* residing around this mangrove-ringed lagoon, including in the author's backyard, where there is minimal harvesting pressure. Crab burrows were measured and enumerated in two 100 m^2 quadrants; one quadrant along the lagoon edge, the other some 20 m from shore in the shade of coconut trees. The results of this survey (conducted in late June 2005) are presented in Table 6.

Table 6: *C. carnifex* burrow size and density on Efate.

Location	Coconuts	Lagoon
# of burrows	208	764
Size range (cm)	1 to 10	0.5 to 18
Mean size (cm)	4	3.3.
Quadrant Area (m2)	100	100
Mean density	2.08	7.64

The burrow density along the lagoon edge was extremely high at 7.64 burrows/m^2 compared with 2.08 burrows/m^2 under the coconut trees. The range of burrow diameters ranged from 0.5–18 cm (with a mean of 3.3 cm) along the lagoon to 1–10 cm (mean of 4 cm) farther inland under coconut trees. The occurrence of numerous small burrows, particularly along the lagoon edge, would indicate significant recruitment to this area during the summer breeding season. The larger mean size among the coconut quadrant would indicate a preference for larger crabs to burrow farther landward. Both mean sizes were less than the 5-cm size of juvenile crabs that were thought to inhabit adult burrows while they matured in the above study. In addition, the author observed a number of 1–4 cm juvenile crabs (carapace width) foraging from dusk through till midnight (at which time surveying ceased) out of their burrows (Photo 10).

Photo 10: A juvenile *Cardisoma* crab found foraging outside of its burrow at night.

These crabs were difficult to observe — if just looking casually — due to their small size, but close observation among the grass and detritus revealed them foraging above ground. Many were observed residing and taking refuge in < 3-cm burrows, as well as larger adult burrows when approached. It would thus seem that *C. carniflex* juvenile crabs in Vanuatu do not necessarily reside exclusively in adult burrows.

The size and age at sexual maturity of Cardisoma crabs remains unresolved for Vanuatu.

6.3 Land crab surveys in Crab Bay

6.3.1 Crab density

Three different methods were used to survey the crab population at Crab Bay. Crab density was measured by counting the number of crab burrows in a 100 m^2 area (a quadrant of 10 m by

10 m). Quadrants were counted among a variety of habitats within the AKTE, ranging from coastal forests, grassy areas, and mangroves, as well as sites outside the AKTE. Sites locations are given in Figure 3.

The results of these surveys are given in Annex 7.1. Burrow density ranged from 0.03–2.87 burrows/m^2 and a mean of 0.74 burrows/m^2 over 18 sites from Crab Bay. Amal burrow density ranged from 0.38–1.59 burrows/m^2 over 6 sites with a mean of 0.77 burrows/m^2. A single site outside the ACTE in the plantation had a burrow density of 2.05 burrows/m^2.

Sites sampled outside of the ACTE on the Crab Bay side averaged a burrow density of 0.53 burrows/m^2 from 4 sites with a range of 0.21–1.05 burrows/m^2. Two additional sites were sampled among garden and plantation areas amongst two crab collection areas around each of the villages of Leoni and Limap. These four village sites averaged 0.77 burrows/m^2 with a range of 15–142/m^2.

Of interest was that the sites sampled in late May 2005 outside the ACTE (including the coastal village sites around Leoni) had many small burrows about 3–5 cm in diameter. These may be considered to be new recruits to these areas, and confirms recruitment outside the ACTE as well as in garden and plantation sites, particularly around Leoni village.

It was important when counting crab burrows to distinguish between the much smaller burrows of the fiddler crabs and those of *Cardisoma* spp. In the Amal mudflat "desert" area, two 100-m quadrants of fiddler crab burrows with a diameter of 3–4 cm, were sampled, and contained densities of 8.82–5.23 burrows/m^2. Fiddler crab burrows were thus smaller diameter and higher density. It was also important to count the more concealed *Cardisoma* burrows that crabs had partially blocked from the inside to be sure to include them. In areas where burrows occurred in high densities, it was found to be easier to count the burrows if the 100 m^2 quadrant was partitioned a number of times internally, and to then count each partition individually and sum the total. This could be done by drawing a line in the soil with a stick, or where this wasn't practical, by laying sticks in a line. To avoid counting the same hole twice, it was useful to mark the counted hole with a leaf.

The burrow densities found at Crab Bay and Amal sites were within the range of burrowing densities reported from other locations such as the Lizard Island sites reported by Quinn et al (1991) where the two sites had burrow densities of 0.75 burrows/m^2 and 0.67 burrows/m^2.

6.3.2 Baited crab counts

The second method used to estimate the crab population was to put bait in various locations and an hour later return to count the number of crabs that were feeding on it (this method was adapted from a local method of baiting crabs for harvesting ease). Dry coconuts were split open and placed among various habitats to get an indication of the crab population foraging in that area. It was found to be effective if the crab bait was placed close to a fallen tree or hollow stump, or alternatively, a pile of coconut leaves or other debris could be placed beside the bait; that way, when the CFs returned to count the crabs, the crabs would take refuge amongst the closest hiding place and could be more easily counted. For logistical reasons this method was done during daylight hours, mainly in the afternoon. This method was therefore also useful in gaining additional information on foraging times and the environmental conditions that influence them. It is likely that these counts would be higher if done during optimal foraging periods (i.e., late afternoons and early mornings). However, transport logistics precluded sampling during that period.

Baiting locations are shown on Figure 3, and the complete results are given in Annex 8.2. The results of daytime baited crab counts over a broad range of sub-habitats within the ACTE ranged from 0–185 crabs after an hour of "soak" time. The highest mean baited crab counts (at 77 crabs normally in a set of six separate baits) were from the "trochus area" and in the northern Crab Bay area with 85 crabs counted. The southern area of Crab Bay had the lowest counts with a mean of 4.8 near the southern boundary and a mean of 19 crabs counted close to

the southern access road. A data set from the entire Crab Bay area yielded a mean crab count of 37 crabs. This compared favorably with a mean crab count from immediately outside the Crab Bay ACTE of 38 crabs.

The lower crab counts in the southern area of Crab Bay may relate to the larger amount of "desert" found there (see Figs. 3 & 4). These desert areas are a result of uplifting and as the soil of this area is salt contaminated, only a few large, older non-regenerative mangroves grow there. Due to the lack of forest cover and shade, the temperatures are much higher and less suitable to crabs. The lower numbers in this area may also relate to the greater harvesting pressure nearby, south of the ACTE boundary.

On the Amal side, baited crab counts averaged 11.7 in December 2004 and 5.8 in early February 2005. Bait counts were thus lower on the Amal side than on the Crab Bay side. This may relate to some harvesting on the Amal side resulting in fewer crabs foraging by day. Because the number of fishers targeting crabs is higher on the Amal side, and with the lack of a clear boundary marker demarcating the ACTE on this side, some fishers inevitably wander into the ACTE.

Also, as the Crab Bay side is more difficult to enter unnoticed (due to the fence clearly showing the boundary and gate in front of the Mapest plantation controlling access), compliance with the closure is higher on this side and crabs forage freely throughout the day. However, on hot, dry days, very few crabs are observed actively foraging during the midday hours and their activity level increases towards the late afternoon. By dusk, crabs are most active. Activity levels were also observed to be high after a rain shower, even during the day's heat. This may have been due to an increase in air humidity after a shower, as well as the leaf material they feed on being more palatable when wet.

6.3.3 Timed crab counts

The third method used to estimate crab numbers was to walk at a constant pace along the access roads of both Crab Bay and Amal and to count the number of crabs seen foraging along the road in approximately equal five-minute intervals. This was done in successive intervals from one end of the road to the other. This method also helped to elucidate the variability in diurnal foraging times of crabs and the environmental conditions that influenced them. This method was derived somewhat spontaneously (and hasn't been seen in the literature) from day after day of driving into the ACTE and seeing numerous crabs, particularly in the Crab Bay side, foraging along the road. A pattern emerged that when entering the area around midday, especially during dry periods, very few if any crabs would be seen. When traversing the area in the late afternoon, there would be so many crabs on the road that someone would have to walk in front of the truck to sweep the crabs off the road with a stick to avoid crushing them. The sweepers' started enumerating them in five minute intervals, and this method was then adopted as an indication of crab density and foraging times.

The CFs would start at the gated entrance to Crab Bay and count crabs along the road and roadside as they walked along the road in five-minute intervals. This would be repeated along successive intervals while walking the entire length of the access road to the Point. This was mainly done between 1400 and 1800 h. Figures were recorded on a prepared data sheet. The full results of these surveys are given in Annex 8.3.

These results show continuous foraging activity from 1400 hours onward, with a general increase towards dusk with a mean of 61 crabs observed/interval during the dry season compared with 100 during the wet season, amounting to a 39% increase in crab foraging between the wet and dry seasons. The area immediately outside of the Crab Bay portion of the ACTE in the Mapest plantation showed a mean crab count of 57 crabs per interval foraging during the wet season, reflecting either lower densities or less foraging during daylight due to harvesting pressure.

Amal was only sampled during the wet season and showed a mean of 25 crabs foraging per

interval during this season, reflecting the lower density of crabs on this side of the ACTE. The appearance of black crabs within the ACTE during the February survey (when the rains had begun) was also evident in these surveys.

6.4 Marine crabs of Crab Bay

*6.4.1 Mud crabs (*Scylla serrata*)*

The mud or mangrove crab is a marine and estuarine crab that is highly regarded for its savory taste, including in hotels and restaurants in urban centers. It is the only marine crab exploited commercially in this area. Adults favor a soft muddy bottom, often below tidal level, and berried females are found well offshore (Brown 1993). They are omnivorous scavengers, feeding on leaf litter, mud as well as other crabs, barnacles, bivalves and dead fish.

In Crab Bay, mud crabs enter the mangroves on high tides to forage, and may burrow into the mud when the tide recedes. Fishers recognize their burrows, visible at low tide, and use a forked stick to extract them. Not everyone is adept at locating and removing them from their burrows and only a few specialists target them. The villagers of Leoni make use of a small holding pen among the mangroves, or simply tether the crabs by their claws before accumulating 3–4 before selling them. The best time of the year for this is the winter, when the tides are at their lowest during daylight hours. In this way, the crabs are afforded some degree of protection from over-harvesting as they are not easily harvested during the summer months when they are more difficult to catch. The summer months are also the time when crabs are thought to spawn (see below), so reduced catches during this critical period further assists with management. One of the main Leoni fishers reports that, in the interests of management, he does not harvest females.

Fishers also catch mud crabs in nets incidentally from the mangroves when they target fish. The crabs they catch are either consumed or sold to a local entrepreneur who pays 600 vatu (VUV)/crab. They are shipped by air to Luganville or to Port Vila for the restaurant market. They are also caught and sold from the adjacent Port Stanley area, primarily by some families from Litslitz village.

6.4.2 Mud crab monitoring and management

The importance of not damaging mud crab burrows, when extracting them with a forked stick for example, should be emphasized to fishers as damaged burrows will no longer support crabs. It is also worthwhile to emphasize the importance of not harvesting females in order to assist with their management. In New Caledonia, the spawning season is from October to March and the minimum allowable size is 130 mm (with research showing that it should be increased to 150 mm, as is case in Queensland, Australia) (Brown 1993). Because no research has been done in Vanuatu to determine a minimum size limit, 150 mm could be adopted as a minimum allowable size by communities around Crab Bay as a precautionary measure. The maintenance of healthy seagrass and mangrove habitats is also considered essential to the maintenance of the mud crab resource (Brown 1993).

The spillover and recruitment effects from not harvesting mud crabs from within the ACTE will assist in maintaining their population in the Crab Bay area. However, as females often swim a distance offshore to release their eggs in deeper water, their potential to be caught in fishers' nets within the open area of Crab Bay is high. Awareness regarding the release of berried females would be worthwhile. Exports to urban centers could be voluntarily recorded by the village-based CFs to monitor their trend over the coming years. In addition, it may be possible to access the Way Bill records of Vanair, the domestic carrier, to get an indication of the weight of mangrove crabs sent to urban centers. This would require their cooperation, as well as the crabs being labeled correctly on the Way Bills. The entrepreneur is reportedly uncooperative in providing export data to DoF, and often ships the crabs labeled as "fish".

Because the Department of Fisheries (DoF) lacks any legislation to allow access to fisheries data at market outlets, data collection from suppliers, wholesalers and retailers remains a constraint to marine resource management in general.

7 Finfish of Crab Bay

7.1 Introduction

To date, there have been no comprehensive surveys documenting the full range of finfish diversity in Vanuatu. However, a study conducted by the Australian Institute of Marine Sciences (AIMS) in 1988 (Done and Navin 1990) used scuba (to depths of 30 m) to document a number of marine resources in select locations throughout Vanuatu. The detailed finfish surveys excluded Malekula. The authors compiled a preliminary checklist of sight records that included 469 species of marine fish from 34 families during these surveys. As identifications were made visually, there was an inherent bias towards fish easily identifiable through visual surveys, and little effort was made to identify more cryptic species.

Done and Navin (1990) found no clear latitudinal variation throughout the archipelago in the structure or species diversity of the fish communities surveyed. Also, they found no major differences between fish communities of platform reefs and those of fringing reefs. They concluded that the finfish communities of Vanuatu were very similar to those of similar sites on the outer shelf reefs of the central, northern and far northern Great Barrier Reef (GBR). This was interpreted to relate to the more-or-less equal distance from the center of diversity in the Indo-Malay archipelago (where some 2,500 species of fish are known (Wright 1993), to Vanuatu and the GBR. A single exception to this similarity in diversity was with parrotfish (Scaridae), which were noted to be of slightly higher diversity than in the GBR.

7.2 General observations on reef habitat and biota of Crab Bay

The AIMS report also made general observations relating to a variety of marine resources, including corals for a number of areas, including Crab Bay. They described Crab Bay as containing highly sheltered habitats and (p: 209), “the leading (seaward) edges of the complex muddy sand and rubble patches were colonized by dense soft coral beds, massive corals, lightly structured foliaceous and branching corals”. The authors observed no live giant clams (Tridacnae), but did find old shells of *Hippopus* on the silt covered reef top inside the bay. Various beche-de-mer species were noted, but none were common. The authors failed to observe any seagrass beds within the bay, but observed seagrass debris floating on the surface. One dugong was sighted but no mention of turtles was made (evidence of the presence of dugongs was recorded throughout the survey, but that of turtles were not).

The greatest diversity of corals was found on the outer reef of Crab Bay (close to MCBT 8). Diversity was lower in inner bay transects than was recorded in the outer bay; there was also an associated shift in species composition to soft corals. This reduction in coral diversity and shift in species composition correlates to the increase in soft substrate, including mud within the inner bay, and associated turbidity as well as freshwater influences.

7.3 Threats

Done and Navin also noted extensive coral bleaching at the time of the survey among both hard and soft corals and that the water was generally turbid and the silt easily disturbed. Only one crown-of-thorns starfish (COT) was seen in the bay, however the gastropod *Drupella* was observed preying upon corals both inside and outside the bay.

The AIMS report also noted the effects of coastal uplifting in the Crab Bay area. They concluded that (p: 209) “It is likely that the raised reef level of recent decades has reduced drainage of the bay, and that as a consequence it is in infilling with sediment, both from the

land, and from the reefs. The crescentic inner margins of the outer reefs are almost entirely reef gravel, sand and rubble."

This suggests that the bay is becoming shallower due to uplifting as well as increased sedimentation due to less tidal flushing. It is possible that the small "mangrove islands" found within the bay (MCBT 6&7) have only recently become well established since recent uplifting and increased sedimentation; no mention of these now significant mangrove stands (Figs. 3 & 4) were made in the AIMS report. Local knowledge supports that these mangrove islands have only recently become well established (Frank Kenneth, Uripiv elder, pers. comm.)

The AIMS report concluded that the status of Vanuatu's reefs was poor (as of 1988), despite the occurrence of many areas of exceptional beauty and interest, and that much of the denigration had occurred since 1985. Factors negatively affecting reefs included 10% of the 35 sites surveyed had active COT outbreaks and, minor to major coral degradation was observed in an additional 20% of locations. Done and Navin (1990) concluded that COT were the single most immediate threat to coral survival in Vanuatu.

In addition, the effects of storm seas associated with cyclones since 1985 (there were eight cyclones, including one severe one affecting Vanuatu during this period) were observed at 50% of the locations studied. Heavy rainfalls associated with a cyclone just prior to the survey may have been responsible for the widespread coral bleaching found in a number of locations. Some evidence for sedimentation smothering corals was also found, again following the heavy rains of cyclones. The effects of tectonic uplifting, including the event discussed affecting mangroves in Crab Bay of 1965, on the reefs of Santo and Malekula were also noted.

While acknowledging the importance of reefs and seagrass beds to the human population (by supporting marine biodiversity and providing protein), Done and Navin (1990) suggested that possibly the most significant financial contribution that reefs provide the people of Vanuatu is in protection and stabilization of coastlines against the destructive forces of storms, cyclones and tsunamis. The authors caution that human-induced degradation of reef ecosystems may tip the balance of equilibrium, whereby new coral growth replaces that impacted by natural causes and results in a loss of this natural protection of coastal areas.

Of note is that the main impacts on coral reefs observed in this survey are primarily of a natural origin (cyclones, heavy rainfalls, uplifting, bleaching, COT) and not human induced. As development of Vanuatu's coastal areas, including in rural areas for luxury waterfront housing, resorts and other purposes is now significantly accelerating, human induced impacts (sedimentation, eutrophication, removal of mangroves, wharf construction, disturbances from motorized boats, etc.) are likely to increase.

7.4 Prior finfish surveys

7.4.1 Mangrove-related finfish surveys

Marshall and Medway (1976), in what is the primary detailed study of the ecology of mangroves in Vanuatu, reported collecting mudskippers from the *Rhizophora* zone of nearby Port Stanley (these samples were subsequently lost and thus not identified). They otherwise concluded that despite Port Stanley have a rich diversity of marine fish that may enter the mangals at high tide, the fish could not be considered a true part of the mangal fauna. It appears that the importance of mangroves as habitat to a range of reef fish juveniles as rearing grounds may have been under-estimated some 30 years ago.

David (1985) surveyed the marine fish in the Maskelynes islands, a small archipelago off southern Malekula, which represents a similar juxtaposition of mangroves, seagrass beds and fringing reef habitats in a sheltered area as found in Crab Bay, although it covers a much larger area (see Fig. 2). David emphasized the refuge that mangroves provide to juvenile nearshore fish along with shoreline stabilization and protection. He also noted their nutrient enrichment

of adjacent waters through the decomposition of the organic matter they produce, particularly leaf litter. In this regard, mangroves were compared with "interest bearing capital" in that they produce immediate yields through the fishing opportunities they offer as well as contributing to future fishing opportunities through nutrient enrichment of the marine environment as well as the feeding and refuge habitat they create.

In the Maskelyne islands, fishermen identified 126 "aquatic species" from 47 families (using photographic references) commonly caught in the mangals and adjacent seagrass areas. This list included more cryptic species, including conger eels and Gobidae (i.e. species not important in local fisheries). Of these, 39 were commonly caught in both habitats, while 45 were only found among seagrasses and 42 only in mangroves[4]. In total, 84 of these species (from 27 families) belonged to the order Perciform, 8 to Anguiliform (2 families) and 6 species (3 families) to Mugiliform. The most frequently represented families were Mugilidae (mullets), Lutjanidae (snappers), Mullidae (goatfish), Siganidae (rabbit fish), Lethrinidae (emporers) and Gerridae (mojarras) (David 1985).

7.4.2 Baitfish of Crab Bay

Data available regarding the baitfish resources of Crab Bay is given by Grandperrin et al. 1982 (quoted in David 1985) as part of an SPC survey of potentially productive baitfish areas for the development of a pole-and-line fishery. These are summarized in Table 7, below.

Table 7: List of baitfish resources reported from Crab Bay.

Family, genus or species	Abundance
Gerridae (mojarras)	Low (10–19% of catch)
Spratelloides sp. (sprats)	Low
Herklotsichthys quadrimaculatus (gold spot herring)	High (50–100% of catch)
Sardinella sp. (sardines)	Rare (0–9% of catch)
Selar spp. (big-eyed scad or "mangaru")	Rare
Cyanocaesio sp. (fusiliers)	Rare
Atherinidae (silversides)	Rare
Rhabdamia cypselurus	Rare
Mulloidicthys sp. (goatfish)	Rare

As can be seen in Table 7, only one type of baitfish was considered to be abundant (*H. quadrimaculatus*). Further baitfish studies concluded that throughout Vanuatu, baitfish resources were insufficient, and were composed of the wrong species (highly seasonal and subject to rapid stock decline when fished) to consider the development of a pole-and line fishery (SPC 1983).

7.5 IWP Crab Bay finfish survey

7.5.1 Survey methodology

Finfish were surveyed by the author and 2–3 CFs using snorkel gear and an outboard powered skiff belonging to the Fisheries Department based at Lakatoro. The tow sample periods were from 6–9 December 2004 and 2–3 February 2005. In consultation with the IWP local coordinator, the RFDO of Lakatoro (who would be responsible for providing ongoing assistance in performing these surveys), and the CFs, it was agreed that the PROCFish

[4] In looking through the list of species designated as "mangrove only", it is apparent that many of these fish may also be found, and caught on coral reefs. Examples include *Platax orbicularis, Lutjanus monostigma, L. bohar, L. argentimaculatus, Plectorhynchus orientalis* and *P. chaetodontoides*.

protocols for finfish surveys would be too complex for the CFs to undertake. This was due to the lack of former training in performing fish surveys. It was agreed to initiate training with a more suitable level of fish surveys that would record the family/genus/species of fishes found to introduce survey concepts and procedures. This training would then be drawn upon by the CFs in performing future surveys for monitoring purposes.

The first step in selecting appropriate survey areas was to do a preliminary habitat and fish survey to observe the range of habitats and diversity of fish found in the Crab Bay area. This was done by the author by using a manta tow that allows a single diver to perform a general survey of a large area in a short period of time. However, within the first hour of performing a manta tow over the large fringing reefs, a large (approximately 2.5 m) shark was observed following the diver, and circling behind him repeatedly. The diver was quickly alerted and retrieved and the survey team managed to locate and observe the shark cruising farther into the bay in barely a metre of water over the fringing reef of Amal. Although it was difficult to positively identify the shark, it resembled a bull shark, which are known to be freshwater tolerant and are found in the nearby watershed of the Pankumo River.

In other parts of Vanuatu, the author has been informed that November-December is the time of year for female sharks to release their pups into nearshore mangle areas (Hickey, unpublished data; two species of shark pups were later observed on the fringe reefs of Crab Bay). Due to the limited visibility of Crab Bay waters (due to freshwater and high nutrient levels from mangals), the occurrence of large sharks in the area, the high probability that it was shark birthing season, and the fact that there had been a shark attack nearby in the previous month, it was decided to abandon the manta tow surveys in the interest of safety.

Instead, the general habitat survey over the fringing reefs was performed visually on mid-to-high tides traveling by skiff to complete a preliminary assessment of the distribution of seagrasses, coral rubble, coral pavement and live coral found on the two large fringe reefs of Crab Bay. Following this, a number of short transects were made over rubble, seagrass and live coral with the author and a CF snorkeling on either side (and the boat remaining close nearby!). The wind was blowing 15–20 knots and the seas were rough over the fringing reefs during the December survey period. This made it impossible to snorkel with a clipboard and waterproof notepaper to record results, as both hands were required to swim in these winds. Also, with the movement of fish, it was difficult to avoid double counting of them by the author and 2 CFs nearby receiving training. For these reasons it was decided to simply indicate to a data recorder (the RFDO) on the nearby boat the species and whether they were P for "plenty" (>20 individuals), M for "medium abundance" (10–19) or S for "small abundance" (1–9).

Because none of the CFs had any former training in identifying fish (in terms of scientific nomenclature), and because Bislama nomenclature is very general, it was decided to spend some time, based on observations of species seen during the reconnaissance surveys, to develop a data recording sheet using both vernacular and scientific terms for fish. This was to improve the accuracy and consistency in recording names of fish. An older CF who was knowledgeable in vernacular fish names was drawn upon to assist with standardizing the names used by the CFs.

The vernacular language used for recording fish names was that of Uripiv, because the other two vernacular languages used in this area did not have a great range of fish names (as these people have stronger links with river and forest resources). Thus, fish names were only recorded in the Uripiv vernacular. The data sheet was continually refined and updated with new fish names as they were encountered and is given in Annex 10. Only the main food fish of the area were recorded, thus excluding the gobies and other small, cryptic species.

An additional advantage to this approach was that it meant the CFs learned many new vernacular fish terms from their elders, and were put in a position of using them while sampling. As vernacular fish terms often include useful TK regarding the habitat or

characteristics of a fish used to more efficiently harvest them, it is important to retain this knowledge (Hviding 2005). As the transmission and strengthening of the use of vernacular terms is also one of the community's objectives, this methodology also served to address this issue.

The selection of fish survey sites was based on the following criteria: 1) accessible in "average" weather conditions; 2) readily re-locatable by CFs without the use of a GPS; 3) representative of the area; 4) acceptable levels of water visibility and diver security.

The marine survey sites primarily recorded finfish, but also noted the occurrence of turtles, dugongs, sea cucumbers (Holothuroidea), giant clams (Tridacnea) as well as general observations on coral cover, sea and tidal conditions, freshwater influences and seabirds. The marine sites are all prefaced with an "M", followed by an "A" for Amal or "CB" for Crab Bay (depending on the area), "T" for transect, and followed by a number. Amal had four marine sites while Crab Bay had eight sites, with two of them being in the middle of the bay where fishing is allowed as indicated in Figure 3. A general description of each finfish survey site is given in Annex 9. These designations appearing on the original data sheets (Annex 10) also include an additional designation of 1 or 2 after A or CB to indicate which field trip the data refers to (the first or second trip). The dates for these two trips are given above.

The position of finfish sample sites as recorded by GPS are given on the data sheets appearing in Annex 10, along with more detailed site descriptions and survey results.

7.5.2 IWP finfish survey results for Crab Bay

Three recognizable, semi-distinct communities of finfish were documented in the Crab Bay area. Those associated primarily with coral reefs, those found inhabiting the seagrass covered fringing reef-flats, and those associated with mangrove habitats. There is a large overlap in these fish communities, with the highest diversity being found along exposed coral reef drop-offs followed by mangroves and finally seagrass covered fringe reefs. The coral reef associated fish are primarily found along the reef drop-offs where coral is abundant and diverse as well as some grazers (primarily acanthurids) found on the limestone flats of the fringe reefs. Some of the reef associated fish community is also found as juveniles, as well as adults, amongst the seagrasses and mangroves. Thus, the nearby mangrove and seagrass areas act as important nursery grounds, providing refuge and feeding habitats to juvenile reef fish as well as a complimentary feeding and refuge habitat for adults.

7.5.2.1 Mangroves

Mangrove habitats may be further broken down between those found in protected, slightly brackish waters (the majority of mangroves in Crab Bay) and mangroves found on the highly exposed fringing reef flats of Amal with very little freshwater influence (primarily *R. stylosa* thickets, with *A. marina* groupings). The latter type (isolated mangrove thickets over seagrass beds adjacent to reef drop-offs) were found to have abundant and diverse fish populations that included the species in Table 8. This species list represents a composite for two sampling events of December 2004 and February 2005 (see Annex 10). Seventeen familes were observed in this unique habitat, represented by more than 23 species. As this thicket dries at low tide, these fish would migrate to deep pools found over the reef flat or to the reef drop-offs. It is likely that they move to these mangrove thickets for feeding purposes as well as the refuge it offers to larger predators (like trevally and sharks) that could not easily penetrate the maze of prop roots. The most plentiful fishes observed in these thickets were the dusky damselfish (*A. septemfasciatus*) along with the two species of large adult mojarras (*Gerres* spp.). Two species of adult snappers (*L. monostigma* and *L. ehrenbergi*) were also exceptionally abundant while the least abundant snapper, *L. fulvus,* was mainly present in juvenile form.

Table 8. Fish found among *R. stylosa* thickets isolated on Amal fringe reef at MAT2.

Family	Genus, species and relative abundance
Lutjanidae	*Lutjanus fulvus* – M
	L. ehrenberrgi – P
	L. semicinctus – M
	L. monostigma – P
Lethrinidae	*Lethrinus harak* – P
Siganidae	*Siganus* spp. – M
Clupeiformes	*Spratelloides* spp. – P
Labridae	*Choerodon anchorago* – S
Gerreidae	*Geres oyena* – P
	G. acinaces – P
Mullidae	*Mulloidicthys vanicolensis* – M
Nemipteridae	*Scolopsis lineatus*. – P
Ballistidae	*Rhinecanthys* spp. – S
Mugillidae	*Crenimugil crenilabis* – P
	Ellochelon vagiensis – P
Acanthuridae	*Acanthurus triostegus* – P
Chaetodontidae	*Chaetodon* spp. – S
Pomacentridae	*Abudefduf septemfasciatus* – P
	Abudefduf spp. – S
Carangidae	*Caranx sexfasciatus* – S
Kyphosidae	*Kyphosis* spp. – S
Teraponidae	*Terapon jarbua* – M
Muraenidae	*Gymnothorax polyurandon* (?) – S

The CFs that assisted in sampling these areas commented that they had never seen such an abundance of "tame" fish. This area served as a positive reinforcement to CFs on the tangible benefits of the closure to fishing in this area.

Only a small number of sea cucumbers (*H. atra*) were observed among the sediments and seagrasses of this area. This may due to the effect of the exposed nature of this site with strong tidal flows washing away the bulk of the detritus produced by the mangroves and associated fauna. Of additional interest was that during the earlier sampling period on 7 December 2004, large numbers of unidentified (presumably) juvenile shrimp were observed hovering just below the surface of the water and remaining relatively motionless. There were none present when this same area was later sampled in early February 2005.

This thicket of mangroves (*R. stylosa*) also supported an estimated 20 reef herons (12 black, 8 white) which flew off when the sampling team arrived by boat on both sampling occasions. In early February, three reef heron nests were observed among the prop roots, including one newly hatched chick (Photo 9).

In traversing this area of Amal, approximately four 1-meter (carapace length) turtles were observed on both sampling days. These turtles were assumed to be green turtles (it was difficult to positively identify them as they sped away) feeding over the seagrass beds.

Many mangrove areas found in sheltered waters with freshwater influence were not practical to sample due to water turbidity and the deep mud substrate that was easily suspended in the

water column resulting in zero visibility. The two areas that were sampled (MCBT4&5), comprised two different mono-specific thickets off a white beach on Crab Bay. MCBT4 is a large stand of *R. stylosa* (Photo 11) whose prop root complex — with a deep pool and long-bladed seagrasses (*Enhalus acoroides*) growing adjacent to it — formed a refuge and feeding area for fish. The composition and relative abundance of the fish community residing in this thicket is given in Table 9 (these data are a composite of two sampling events as described in Annex 10).

Photo 11: The mature monostand of *R. stylosa* used as a finfish sample site at MCBT 4.

Table 9. The relative abundance of fish found among *R. stylosa* prop root complex at MCBT 4.

Family	Genus, species & relative abundance
Siganidae	*Siganus fuscescens* – S
Gerreidae	*Gerres oyena* – P (mostly juveniles)
Carangidae	*Caranx sexfasciatus* – S
Lethrinidae	*Lethrinus harak* – P (including juveniles)
Lutjanidae	*Lutjanus fulvus* – P (juveniles)
	L. monostigma – P (sub adults)
	L. ehrenbergi – P
	L. argentimaculatus – S
Apogonidae	*Sphaeramia orbicularis* – P
Mugilidae	*Crenimugil crenilabis* – M
	Unidentified "white mullet"
Chaetodontidae	*Chaetodon* spp. – S
Pomacentridae	*Abudefduf septemfasciatus* – P (including M juveniles)
Teraponidae	*Terapon jarbua* – S
Dasyatidae	*Taeniura meyeni* (?) – S (1 large individual in sand)
Plotusidae	*Plotosus lineatus* – (school of 100)
Sphyraenidae	*Sphyraena* sp. – S (juveniles)
Serranidae	*Epinephilus maculatus* – S (1 juvenile only)

A total of 18 species from 13 families were recorded from MCBT 4.

The contiguous large monospecific stand of *A. marina* at MCBT5 (Photo 3) just west of MCBT 4 (which was in shallower water with less current and more freshwater influence from shore seepage) showed a similar community of fish but with less diversity (Table 10) (the full data set for this transect is found in Annex 10).

Table 10. Relative abundance of fish found amongst large monospecific stand of *A. marina* with freshwater influence.

Family	Genus, species & relative abundance
Gerreidae	*Gerres oyena* – P (mostly juveniles)
Lethrinidae	*Lethrinus harak* – P (juveniles & adults)
Lutjanus	*Lutjanus fulvus* – S (juveniles)
	L. monostigma – M (subadults)
	L. ehrenbergi – M
Mullidae	*Mulloidicthys* sp.- S
Nemipteridae	*Scolopsis lineatus* – S
Mugilidae	*Ellochelon vagiensis* – P
Belonidae	Unidentified juv needlefish – S

A total of nine species from seven families were documented from the *A.marina* complex that also had more freshwater influence and less tidal flow. However, it may be the lack of surface area of the *A. marina* pnuematophores and trunks (compared to the prop roots of *Rhizophora*) for epibiota and refuge for fish that is responsible for this reduction in diversity.

7.5.2.2 Fringing reefs flats

The seagrass beds growing over limestone flats in coarse sand dominate both large fringe reefs (along with patches of coral rubble and pavement) were noted to be relatively species poor for food fish when surveyed. The dominant species of seagrass (not identified) is short bladed and exposed to southeast trade winds, strong tidal in-and-outflows as well as the scouring effects of cyclones. The majority of these large fringe reefs dry at low tide, especially during winter low tides, at which time these seagrasses are barely in 1 cm of water (Photo 12).

Photo 12: The fringing reef of Crab Bay (looking southeast) exposed on a low spring tide.

These exposed fringing reef areas were characterized by a limited range of species. Species diversity increased in areas where the coral pavement was broken up by the occurrence of large stones, crevices and holes that provided refuge from the exposed seas and strong tides of the area. (For example, at MAT1; Photo 13).

In areas of mixed seagrass, coral rubble and pavement, fish were primarily represented by convict swurgeons (*Acanthurus triostegus,* Acanthuridae), triggerfish (primarily *Rhinecanthys aculeatus,* Balistidae) that takes refuge in the numerous

Photo 13: Two CFs sampling the rock formation of finfish sampling site MAT1 on Amal.

holes and crevices of the limestone flats, emperorfish *Lethrinus harak* (Lethrinidae), and in areas (e.g.) where there were large stones, more crevices and holes were found the spinecheeks (*Scolopsis* spp., Nemipteridae) and the half-barred snapper (*Lutjanus semiscinctus*, Lutjanidae) became plentiful with a small number of smaller groupers (Serranidae). Mullet (primarily *Ellochelon vagiensis* and *Crenimugil crenilabis*), rabbitfish (Siganidae), needlefish (Belonidae) and halfbeaks (Hemiramphidae) were also recorded in the water column over seagrass beds, primarily during mid to high tides. Siganidae were not recorded frequently, but presumably grazed on the epibiota of the seagrasses. Because these fringing reef areas were frequently dry, particularly at spring tides, most of these fish sought refuge in deeper pools on the reef flats or migrated to adjoining areas, either the deeper water of the bay or seaward to the reef drop-off during low tides.

While surveying in November 2004, a number of juvenile blacktip sharks were encountered near the trochus outplant site (MCBT3). The two 30–40-cm juveniles were quite aggressive and not easily scared off. The Fisheries Research Section personnel involved in surveying trochus also noted aggressive juvenile blacktip sharks during the course of their surveys (Robert Jimmy, pers.comm.). An additional unidentified lobe-finned juvenile shark (possibly the bull shark, *C. luecas*, known to be freshwater tolerant and found in the nearby Pankumo river system) was also noted in this area at the same time. The RFDO also noted an estimated 50 juvenile blacktip sharks in the vicinity of nearby transect MCBT4 (a thicket of *R. stylosa*) in mid-February 2005. These observations suggest that the Crab Bay area is used by blacktip and possibly other species of sharks for releasing live pups. The release of shark pups in mangrove areas has also been documented on nearby Maskelyne and Emae islands (Hickey, unpublished data).

The CFs indicated that large adult sharks, including blacktip and other species, are also frequently observed in the Crab Bay area and many of the CFs expressed concern when snorkeling there. In many areas of Vanuatu, large baited hooks are anchored or set on large floats to reduce the number of dangerous sharks in an area. This is an option for the ACTE MC to consider if they feel it is necessary for safety reasons.

Photo 14: The RFDO showing one of the large giant clams (*H. hippopus*) placed in a breeding circle within Crab Bay.

The main commercially important invertebrates documented from the fringe reefs included the lollyfish (*Holothuria atra*) sea cucumber among the seagrass beds. The green sea cucumber (*Stichopus chloronatus*) was found along the fringing reef perimeter where coral pavement dominated. A single blackteat (*H. nobilis*) was observed at MAT1. Nowhere were sea cucumbers noted to be particularly abundant.

Giant clams were observed at the more exposed coral reef transects. A CF from Leone created a breeding circle by collecting and placing a number of giant clams (mostly *H. hippopus* and some *T. squamosa*) on a soft bottom within Crab Bay north of MCBT7 (Photo 14).

Hippopus did well, but *T. squamosa* died, presumably due to the turbid waters and sedimentation of the soft bottom. The CF was advised of the differences in habitat requirements between species and was encouraged to select another site with a firm substrate for *T. squamosa*. Given the paucity of giant clams (presumably due to subsistence pressure prior to reef closure), the creation of breeding circles as a management method should be encouraged.

7.5.2.3 Exposed coral reef drop-offs

The light and variable winds associated with summer during the second field trip in early February afforded the opportunity to sample the fringing reef drop-offs of Amal and Crab Bay (Table 11). During the initial trip in November, the strength of the southeast tradewinds made snorkeling these drop-offs impractical. Survey data for these two transects (MAT4 and MCBT8) are given in Annex 10. Both of these areas experienced a plankton bloom when sampled in February, and an impressive array of large zooplankton was visible in these waters (the stinging tentacles of jellyfish were also very apparent). On the Amal side, freshwater springs draining through porous coastal limestone were visible as a mixing layer. Although no springs were found off the Crab Bay side, there was a plankton bloom along the drop-off there.

Table 11. Reef associated fishes found at exposed reef drop-offs.

Family	Genus, species & relative abundance
Serranidae	*Plectropomus leopardis* – S
	Epinephelus spp. – S
Holocentridae	*Sargocentron* spp. – S
Clupidae	Unidentified – P
Labridae	*Epibulus insidator* – S
	Cheilinus undulates – S
	Gomphosus spp. – L
Carangidae	*Caranx melampygis* – S
Scaridae	*Scarus* spp. – P
Lethrinidae	*Monotaxis grandoculus* – M
	Lethrinus spp. – M
Lutjanidae	*Lutjanus fulvus* – P
	L. gibbus – P
	L. monostigma – M
	L. bohar – S
	Macolor niger – S (including juveniles)
Mullidae	*Parapeneus* spp. – M
Ballistidae	*Ballistoides viridescens* – S
Acanthuridae	*Acanthurus lineatus* – P
	A. xanthopherus – M
	Acanthurus spp. – P
	Naso sp. – M
Chaetodontidae	*Chaetodon* spp. – P
Haemulidae	*Plectorhinchus lineatus* – M
	P. chaetodonoides – S
Pomacentridae	*Abudefduf* spp. – P
Kyphosidae	*Kyphosus* sp. – M
Caesionidae	*Caesio* spp.

As it had rained heavily the previous week on Malekula, the nutrients leached from inland forests and mangroves had stimulated plankton growth on the outside of the Bay. The light

westerly winds, not uncommon during the hot season, perhaps contributed to the transport of nutrients from Crab Bay towards the eastern reef drop-offs as well as via underwater springs. Feeding on the plankton of these reef drop-offs were sardines (Clupidae) and fusiliers (*Ceasio* spp.).

There were more than 28 species from 16 families recorded from the outer reef drop-offs (see Table 11; this list represents a composite of the two exposed drop-offs sites surveyed). These numbers are an under-estimate due to the depths to which these drop-offs extend (estimated to be at least 30 m). A more thorough survey of these reefs, using scuba, should be made (this would also add a margin of safety in the event of encountering sharks). While fish size was not estimated, it was apparent that the fish found along the drop-offs were generally large relative to the reef drop-offs sampled from more protected sites such as MCBT1 & 2, and MAT3. This would in part be explained by the considerably less fishing pressure on these reefs in the past due to their relative inaccessibility due to their exposed nature.

7.5.3 Difference between fished and closed reef areas

The fished areas surveyed were the two "mangrove islands" within the open part of Crab Bay (MCBT6 & 7). MCBT6 had only six families represented while MCBT7 had only four families on a low tide and nine on a high tide. This difference would be attributable to the increased feeding and refuge opportunities available on a high tide. While the number of families is relatively high for MCBT7 on a high tide (i.e. nine families), the number of individuals found at these locations (both MCBT6 & 7) were noticeably lower, smaller and more wary of divers. This is most likely a direct outcome of fishing pressure on these areas.

7.5.4 Effects of uplifting on coral reefs and seagrass beds

It is quite possible that the two large fringing reefs associated with the two headlands within the ACTE are in transition due to uplifting. These reefs are now largely intertidal, and are partially covered in seagrass beds that grow on a coarse sand layer over a limestone base (coral pavement), with isolated live coral heads distributed in deeper pools and along the seaward edges. One could hypothesize that with the abrupt uplifting known to have occurred in this area of Malekula, the live coral that formed and once covered these fringe reefs has been replaced by seagrass beds.

Research has shown that corals are rarely found at the upper limits of exposure to competition or other factors, such as wave exposure, and thus, intertidal or shallow subtidal colonies may be rare despite a well developed coral community a few meters below sea level (Taylor et al. 1981). As the two fringe reefs were obviously formed by coral growth in the past, it appears that the effects of uplift has resulted in a shift to seagrasses, which in general, are more tolerant to sunlight and desiccation (Leon Zann, pers. comm.). If this trend in uplifting continues, these seagrass beds may eventually give way to coastal lowland forests, just as the two headlands, also composed of limestone, no doubt have in the remote past.

8 Shellfish of Crab Bay

8.1 Trochus

Trochus stocks were not surveyed as part of this Ecological Baseline Survey because the DoF has been monitoring trochus in Crab Bay since 2003. As part of a regional Australian Centre of International Agricultural Research-funded trochus restocking programme, an alternative restocking method to out-planting trochus juveniles is being trialed at three sites in Vanuatu. This method involves the placement of adult trochus in metal mesh enclosures attached to coral pavement to allow reseeding to occur through natural spawning.

Following this approach, the DoF placed 400 adult trochus in a 50 m^2 wire mesh cage in May

2003 on the Crab Bay fringe reef at MCBT3. This area is locally referred to as the "trochus site". The 9–12 cm in diameter adults were collected from the general Crab Bay and Amal fringe reef areas and placed in the cage for over one month. This duration would allow for at least one spawning event, which normally occurs close to the new moon throughout most of the year with a spawning minimum during colder winter months (Rob Jimmy, pers comm.). Due to the high density of adult trochus in the enclosure, it was not possible to leave them for longer periods. Cyclones and rough seas will also destroy these enclosures. A trochus control site was established on the Amal fringe reef at MAT3.

Initial trochus surveys on the fringe reefs prior to reseeding revealed an estimated average of 33 adult trochus/hectare (ha) for Crab Bay and 16 trochus/ha for the control site on Amal. Surveys of juvenile habitat found no juveniles at either site prior to treatment (Robert Jimmy, pers.comm.). Six months after reseeding, quarterly surveys of the trochus and control sites commenced. The most recent survey undertaken of adult habitat by the DoF in April 2005 (two years after reseeding trials commenced) estimated 567 trochus/ha at Crab Bay and 560 trochus/ha on Amal. Surveys of juvenile habitat estimated densities of 583 juveniles/ha at Crab Bay and 400 juveniles/ha on Amal (Robert Jimmy, pers. comm.)

The adult and juvenile trochus density averages as estimated over the three sites (on Malekula, Pentecost and Epi Islands) as part of this study were 22 juveniles/ha and 100 adults/ha prior to treatment. After treatment two years later, juvenile trochus density averaged 794 juv/ha and 728 adults/ha over the three sites. These averages are relatively high due to the numerous traditional reef closures found at Pentecost as well as their tendency to rely on kava production for generating revenue and consequent reduced trochus harvesting pressure (Robert Jimmy, pers.comm.).

It is clear from these figures that trochus recruitment to both reefs of the ACTE has increased significantly over the last two years. It may also be the case that trochus spawned on Crab Bay during treatment effectively recruited to Amal through downstream effects (the predominant current in Vanuatu being easterly/southeasterly) as well as naturally from Amal adults.

An important part of the success in increasing trochus stocks is the high compliance with the closure to all fishing within the ACTE during the period of this study. With ongoing compliance of with this closure, it is anticipated that high trochus densities within the ACTE will assist in replenishing trochus stocks to the surrounding reefs through larval export effects. As the trochus larval stage is short, approximately four days, local recruitment to home and nearby reefs is highly likely (Nash 1993).

The DoF trochus surveys were undertaken with the assistance of two community members who received training in trochus surveys. These two CFs were also involved in the finfish surveys performed as part of this Ecological Baseline Survey and will be able to assist with ongoing trochus monitoring.

Reefs outside the ACTE should be monitored for increases in trochus population an ongoing basis. Current advice from DoF is to leave the trochus closure in place for another three years to allow new recruits to reach the legal size of 9 cm basal diameter (growth rate in Vanuatu is found to average 3 cm/year). Once stocks outside the ACTE are found to recover sufficiently, it may be advisable to restrict trochus harvests to short openings when size restrictions may be more easily monitored. These short openings may best be timed to coincide with winter months when spawning is least likely to occur due to cooler water temperatures (Robert Jimmy, pers. comm.).

Trochus openings in the ACTE area should be controlled by the surrounding stakeholder communities and their traditional leaders as advised by the MC with the assistance and support of the DoF. Village-based trochus closures are one of the more common marine resource management measures found in Vanuatu (Johannes and Hickey 2004)

8.2 Other molluscs

Other molluscs of Crab Bay and Amal were surveyed by collecting dead shells among the mangroves, reefs, beaches and seagrass habitats and while snorkeling the area. This survey was not exhaustive, but yielded approximately 50 species from these various habitats.

The main species targeted commercially for sale in the Lakatoro market are under the greatest fishing pressure. These species include (vernacular terms in the Uripiv language): the small *Turbo* species (*nelil*) such as *T. setosus* and *T. chrysostomus*, *dirong* (*Polymesoda erosa* or *Batissa violacea)*, *banu (Anodontia philippiana),* the mud whelk *(serwok)* (Photo 15),the mangrove litorinid, *sasurong* and occasionally the surf clam *Atactodea striata* and mangrove oyster (*narbaso*) *Saccostrea cucullata*, which is also sold to urban markets. The chiton (*diwud*) *Acanthopleura* sp. is also sold in the Lakatoro markets.

Photo 15: Numerous serwok are found in the mangroves of Crab Bay within the AKTE. Serwok is commonly targeted for subsistence as well as sold in the market.

In addition, *nari*, or small cowry shells (*Cypraea* spp.), are sold for use in creating jewelry and other decorative items. These are harvested live and cleaned for sale to handicraft makers.

The utilization of these mollusks in the markets may be monitored most easily within the market itself. Whenever possible, and especially on Fridays when greater volumes are sold, the date, vernacular name, approximate quantity (i.e. plastic bag, coconut leaf basket) or other appropriate unit and place of origin and seller should be recorded by the Provincial official at the market. Forms, with spaces for the above info should be prepared by IWP in conjunction with the RFDP and province. These data should be collected daily and entered monthly into a database (or spreadsheet) at the Fisheries office in Lakatoro or Port Vila.

Other mollusks consumed by residents in the Crab Bay area and their vernacular terms are listed in Annex 11, along with their habitat and traditional uses for them. The closure of Crab Bay will assist significantly as a reproductive reservoir of these species to the surrounding area. Monitoring could be accomplished by regular interviews with residents, particularly women involved in shellfish collection to elucidate changes in stock levels including a reduction observed by the collectors.

9 Turtles of Crab Bay

Of the seven marine turtle species found globally, at least four different species are found on Malekula. These include the more commonly found green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles, along with the less commonly observed loggerhead (*Caretta caretta*) and leatherback turtles (*Dermochelys coriacea*) (Environment Unit unpublished data, Petro et al., Hickey and Petro 2005). Based on turtle descriptions by residents, it is also possible that the olive ridley (*Lepidochelys olivacea*) and the flatback (*Natator depressus*) is found around Malekula. This species diversity reflects the broad range of coastal habitats found on the relatively large island of Malekula.

Turtles were regularly observed in the Crab Bay area during the course of this survey. Of the four days spent traveling by boat within the area surveying finfish, on average, four turtles were seen per day. Most of these were observed while traveling over the fringing reefs and were assumed to be feeding on the seagrass growing there. These turtles were thus assumed to be green turtles, an assumption supported by the large size of some of the turtles (green turtles grow much larger than hawksbills). One turtle was observed outside of the fringe reef along the reef drop-off close to MCBT8 and another on the Amal side in the MAT3 area. These turtles, smaller in size, were assumed to be hawksbill turtles feeding off coral reefs there (their diet includes sponges, shellfish and algae).

The presence of these two species of turtles in the area is supported by their two prime habitats being present in great abundance in this area (seagrass beds for green turtles and coral reefs for hawksbills). The Uripiv vernacular terms also support that these two species are present in this area. N*evu* is the general term for turtle. *Nevu jok* refers to a hawksbill turtle (*jok* is a type of yellow banana when ripe, and is equated with the color of the hawksbill head). *Nevu mok* (*mok* translates as black or dark) refers to the green turtle because its shell is often black. N*evu mok* is known to eat seagrass.

Nevu mir (meaning "round and short") is possibly the flatback. *Nevu jarl* (meaning to "float") always remains small, even when old, and is tentatively identified as the olive ridley. *Devin mal* is another term recorded and possibly refers to a young olive ridley. This turtle is said to remain close to shore and is unwary and doesn't always try to escape.

No term was suggested for the leatherback by Uripiv language speakers. Their unfamiliarity may stem from the lack of suitable nesting habitats in their immediate area. However, the leatherback is still known to nest at the black beaches along the wider area of central eastern Malekula, as well as at various black beach areas around Malekula (Petro et al. in press). The decline in leatherback nesting populations in Vanuatu has been ongoing. Many islands have not had leatherbacks nesting them for 20–30 years (Petro et al. in press). Local informants indicate that one was eaten from nearby Sarmette beach (beside Mapest plantation) around 1996 and no more nesting has occurred since then.

The beach at Bushman's Bay adjacent to Amal is also prime leatherback nesting habitat (i.e. a long black beach with little fringing reef development and a river), but there is no memory of their nesting. This may stem from the early alienation of this land during the early-mid 1900s and the presence of beach front housing for colonials and plantation staff. Malekula residents indicated that a leatherback came ashore to nest on 11 December 2004 at the black beach of Aulua village some 20 km south of Crab Bay. This leatherback was observed by many people, not harmed and safely returned to sea. It is not clear, however, whether it successfully nested or not, or whether hatchlings emerged.

The support for leatherback nesting and the reduction in subsistence catches of them and their eggs, is particularly important, as this species is now considered to be critically endangered in the western Pacific (Spotila et al. 1996). They are known, however, occasionally eaten on Malekula as well as other areas of Vanuatu. For this reason, it is important that further awareness regarding the leatherbacks' threatened status be provided to communities around Malekula to assist with their management.

Of all of the turtle species, local informants observed that the *nevu mir* (possibly the flatback), olive ridley, and the leatherback do not nest on the sand beaches of the Uripiv Island area, while the other species listed do. Only the green and hawksbill turtles are considered to commonly nest in this area.

Three turtle nesting events and one hatchling emergence, involving either green or hawksbill turtles, within the ACTE were documented during this survey as outlined below.

On 26 January 2005, a turtle nest was found by the RFDO on the Crab Bay side between site TCBT1 and the Point. The RFDO considers that judging from the size of the track left by the

turtle and the deep scrapes it left on the shrubs in the area that it was most likely a green turtle. The nest position was at 16 09.822 S; 167 32.590 E.

Chief Manua Kaun, a CF from Leoni village, had also found a nest in the same general area approximately one week earlier. The nest position was 16 09.839 S; 167 32.217 E.

On 4 February 2005 a new turtle nest was observed 4–5 m (horizontally) from the HWM close to Crab Bay Point. It was just south of an old truck chassis off the side of the road (discarded during colonial times).

On 31 January 2005 at approximately 1600 h, the CFs observed a number of hatchlings emerging from the grassy area right at the northern point of Crab Bay. The hatchlings appeared disoriented and unable to locate the sea some 10 m away over level ground but obstructed by tall grass. One of the CFs made splashing noises in the water to assist their orientation and this appeared to help. The next day at noon, one dead hatchling was found among the grass at this site and was collected, photographed and kept refrigerated for later identification. This hatchling was later identified from these photographs as a hawksbill turtle (based on its four costal scute arrangement) (Kirstin Dobbs, Great Barrier Reef Marine Park Authority, pers. comm.).

Green and hawksbill turtles are also considered endangered species and are listed under the Convention on International Trade of Endangered Species (CITES) Appendix I. Vanuatu is one of four South Pacific nations to have joined CITES. Although there is very limited data on turtle populations within Vanuatu, there is a general consensus among coastal communities that turtle populations have declined significantly over the last 25 years. This may be attributed to changes in hunting techniques, including the use of outboard-powered boats, metal-tipped spears, spearguns with floats, and the widespread use of snorkel gear to spear turtles in resting areas (Hickey and Petro 2005). Consumption of turtle eggs throughout most of Vanuatu has also been the case since at least the 1980s (Hickey and Petro 2005), although they rarely, if ever, are sold in public markets.

Early European visitors to northeast Malekula made the following observation regarding turtles and turtle egg consumption. Elkington (1907:181) sailed through this area in the late 1800s and commented, “Turtle fishing is not gone in for much, as the natives are superstitious about the turtle…….One of the chief ones is that the eggs are sacred and may not be eaten.” Sommerville (1894:377) similarly noted for the same area, “Turtles are very common around the reefs, but are seldom caught. The…..people will not eat turtle eggs…at Uripiv.”

Hickey (in press) also notes a number of traditional turtle-related taboos found throughout most of Vanuatu that served to decrease fishing pressure on turtles and their eggs, particularly during nesting season. These practices included prohibitions against consuming turtle meat or eggs, and going to yam, water taro, and other gardens. As the highly esteemed yam gardens were planted and tended during the turtle nesting season, this served to significantly reduce fishing pressure during their most vulnerable period. It was also taboo for children and pregnant women to eat turtle meat or eggs in many areas of Vanuatu, as it was believed this led to children developing sores. In some areas, turtle consumption was taboo for those with asthma, as it was found to aggravate their condition. Totemic affiliations with turtles also accorded restrictions in harvesting pressure in many areas of Vanuatu. Also, in some areas with Polynesian influences, turtles are considered to be the food of traditional leaders and are thus not harvested uncontrollably.

Many of these beliefs and practices are not followed by the younger generation in most areas today. Many of the older generation continue with these practices, however, and often find that their yam gardens are more productive when these taboos are respected. A similar taboo against consuming turtle and going to gardens exists in Papua New Guinea, and the author was told by local informants there that it was to keep the pungent odour of turtles out of gardens, so that wild pigs, known to dig out yams and other crops, would not be attracted to them and

damage gardens.

To counter the regional trend in turtle population decline, the Secretariat of the Pacific Regional Environment Programme (SPREP) initiated the "Year of the Turtle" among member countries in 1995. Awareness was promoted throughout the region regarding the threatened status of turtles. In Vanuatu, a local theatre group called Wan Smolbag scripted a play on the plight of the turtle that simultaneously educated and entertained villagers. A village-based "turtle monitor" network was established as part of this programme and these monitors, working closely with their traditional leaders, assisted in re-enforcing the need for turtle management within the village as well as well as tagging turtles as part of a regional programme.

This programme has since evolved into the Vanua-tai Resource Monitors network (VTRMs), and provides awareness on a range of environmental and resource management issues throughout the archipelago with a network of approximately 200 monitors (Hickey and Petro 2005). In a survey of the evolution of village-based management of marine resources within Vanuatu, it was found that in 1993, no villages of the 21 surveyed had restrictions on turtle harvesting or egg consumption, while in 2001, 11 of the 21 villages had introduced taboos on killing turtles and eating turtle eggs (Johannes and Hickey 2004)

An increase in turtle harvesting from Uripiv residents, now one of the main turtle hunting villages in the area along with Uri, began around independence in 1980 (Numa Fred, Malekula Cultural Centre, pers. comm.). Leoni villagers stopped eating turtles and their eggs in 1999, although compliance may not be 100% (Manua Kaun, pers. comm.). This area of Malekula could benefit from joining the VTRM network in order to increase awareness regarding turtle management and other resources, in an area of prime turtle habitat and known to have at least four species of turtle.

10 Dugongs of Crab Bay

Vanuatu is the easternmost limit within the Pacific known to have the globally endangered dugong (*Dugong dugon*) (known as *buris* in the Uripiv vernacular). It is found widely distributed in shallow, coastal tropical and sub-tropical waters from east Africa to the southwest Pacific, but has been extirpated or greatly reduced in numbers throughout much of its range in the recent past. This marine mammal feeds primarily on seagrasses. It is protected under the Fisheries Act of 1982 along with all other marine mammals. Despite this protection, it is very difficult to enforce this regulation in rural areas due to the limited enforcement capacity, in terms of financial and human resources, of central government. Until relatively recently, most communities were unaware that there was a law prohibiting harming dugongs (Hickey and Petro 2005).

A survey of the status of dugongs in Vanuatu by way of a postal questionnaire and aerial survey was undertaken in 1987 (Chambers et al. 1989). This survey indicated that dugongs were reported from nearly 100 locations, including all of the major islands and island groups. They were only found in relatively small social groups (unlike areas in the Torres Straits of Australia) with only three locations reporting groups greater than 10 individuals. Most areas indicated that dugong numbers were either stable or increasing. No evidence for long or inter-island migration was found, although movement along coasts was common along with between closely associated islands.

Dugong hunting was reported from a few locations of Vanuatu with a larger number of areas indicating they were caught on an opportunistic basis, for example when found stranded by a falling tide. Hunting mortality was concluded to be low, even in areas where they were hunted. Dugongs were not normally killed for ceremonial purposes nor were many stories recorded regarding traditions associated with the dugong.

Chambers et al.1989 indicated that the dugong does not appear to be in danger of decline or

extirpation in Vanuatu. The authors reported that the very threats in other countries to dugongs — such as overhunting, habitat alienation, high accidental death rates and pollution — do not exist in Vanuatu, nor will they be in the foreseeable future. Vanuatu, the authors conclude, may be one of the few countries in the dugong's wide distribution where its population is secure.

Since this survey in 1987, not much regarding dugong threats has changed significantly in Vanuatu, with the exception of 1) an increase in the number of motorized boats that may cause accidental damage to dugongs, and 2) the use of long monofilament nets that may drown dugong calves (Hickey and Petro 2005). It is reported that adult dugongs are powerful enough to break free from the nets, thereby damaging them, and these areas are avoided by fishers for this reason. With the increased awareness regarding national regulations that protect dugongs, including through VTRMs, it is likely that less opportunistic dugong kills now occur in most areas of Vanuatu (Hickey and Petro 2005).

However, increased coastal developments in the form of luxury waterfront housing and resort development in rural areas of Efate (and increasingly on Santo since 2004; pers. observ.) may result in increased sedimentation, eutrophication and degradation of seagrass habitat, and affect the distribution of dugongs. A further increase in the number of motorized pleasure craft is likely following these developments.

Chambers et al. 1989 reported a single resident dugong in Crab Bay, as well as one in nearby Sarmette, 2 in Bushman's Bay, and from 3–10 dugongs found in each of the following nearby locations: Lakatoro, Uri, Uripiv, and Port Stanley. Taking a conservative average estimate of 5 dugongs for each of the locations thought to have 3–10 dugongs, this indicates 24 dugongs from Lakatoro to Sarmette. Uri Island respondents indicated that dugongs appeared, mainly in June and July.

Until the resource management awareness associated with the ACTE, residents around Crab Bay reported occasional opportunistic dugong kills in the area by the residents of most villages. Uripiv residents also reported formerly hunting dugong by corralling them among mangroves. They could then be killed through suffocation by inserting mangrove prop root tips into their nostrils (Frank Kenneth, Uripiv elder, pers. comm.). This, however, is not practiced anymore.

An interesting development regarding dugongs in Vanuatu is the taming of them in some areas, primarily to attract tourists. This has been done on Tanna at Port Resolution (this dugong died, apparently of natural causes, in 2001) as well as at Lamen Bay on Epi. The Lamen Bay dugong continues to allow tourists to swim nearby and observe it feeding and even touch it, and has become an attraction for tourists. In both cases it was a woman that tamed the dugong.

The CFs estimate that the current population of dugongs within Crab Bay is currently between 6 and 10. This is a significant increase from the estimate of 1 in 1987. It is recommended that dugong numbers in Crab Bay would make a suitable indicator species because they are 1) an endangered species, 2) relatively easy to enumerate by fishers and CFs who spend long periods in the area throughout the year, and 3) their population will reflect the extent of seagrass coverage and lack of disturbances within Crab Bay.

Estimates of the resident dugong population should be recorded annually by the CFs, along with indications of seasonality, important feeding areas, mating and calving. Timing of mating and calving would also be useful information to collect for management purposes as little is currently documented. Monitoring feeding areas and any changes in them will assist in monitoring changes in seagrass coverage within the bay. The primary threats to seagrass coverage are cyclones and tectonic uplift. Medium- to large-scale logging upslope of Crab Bay and resultant sedimentation could also affect seagrass coverage.

11 Seagrasses of Crab Bay

Four types of seagrasses are distinguished by the people of Leoni. *Nulas* is the generic term for seagrass in the Uripiv vernacular. *Nanen nga nevu*, which translates as "food of the turtle" is a short seagrass found over the fringing reefs and within the bay, and is the most common one found there. The descriptive name *nulas nga murol,* which translates literally as "short seagrass" was also given. It was estimated that it covered approximately 50% of the two large fringing reefs of Amal and Crab Bay. Closer to shore in less exposed areas with slightly deeper water, *Enhalus acoroides (nulas nga miprev* or "long seagrass") is found. This longer seagrass was found to be plentiful in the vicinity of MCBT4 in areas where water depth increased. These two types of seagrasses are shown in Photo 16.

Inside the protected waters of Crab Bay, the finer seagrass *Halophilia* sp. is found growing in finer sand, for example, in the vicinity of the mangrove islands MCBT7 and T6. This seagrass is also termed *nanen nga nevu*, or "food of the turtle". It is also said to be the preferred seagrass of the dugong (Frank Kenneth, pers. comm.)

Photo 16: The two main types of seagrasses found in Crab Bay close to MAT4; long bladed (*E. acoroides*) and the short bladed. A sea cucumber (*H. atra*) is also visible.

An additional "seagrass", called *nanen se buris* or "food of the dugong", was found at the HWM in the Crab Bay area. This was identified as the littoral, salt-tolerant *Sesuvium portulacastrum.* Dugongs are locally known to feed on this succulent herb on very high tides, and it is also a traditional food of Limap residents.

12 Lessons for IWP

The following lessons — regarding further support for similar resource management initiatives at community, provincial, national and regional levels — draw on the research carried out for this report, as well as experiences with other resource management initiatives in Vanuatu.

- It is important to allow both an adequate time frame and sufficient flexibility to allow the community consultative process to be thorough, complete, and to be compatible with the rate of behaviour change associated with rural village life. More time is needed when multiple communities are involved; the five-year time frame for IWP has been sufficient, given that the communities involved had already initiated the resource management initiative prior to the commencement of the IWP project.
- The consultative process must include a broad spectrum of stakeholders, including elders, women (who hold much of the TEK), youth, artisanal and commercial fishers, land, reef or leadership claimants, and relevant provincial and national government bodies.
- It is important to create strong links between CFs and MCs such that the group receiving much of the awareness and education (the CFs) are also part of the

decision-making processes (primarily vested with the MC).

- The project should be roorted in local traditions, thereby strengthening and promoting local ownership of the project while acknowledging and supporting existing traditional resource management systems and promoting their transmission to ensuing generations.
- There is a need to promote — on a regional, national and provincial level — greater awareness of the importance of developing stronger recognition and support for traditionally-based village resource management initiatives. Government departments, regional organisations and aid donors sometimes promote, fund and support the introduction of western-based models, which may be inappropriate for Vanuatu's rural communities, and may serve to further erode and denigrate indigenous management models.
- It is important to support capacity building for traditional community leaders in the area of community governance, and to assist them in fulfilling their pivotal roles regarding village level resource management.
- It is importante to build, at the national level, the capacity of the Department of Forestry's Forest Conservation Unit (FCU) to identify the full range of mangrove species found in Vanuatu (they have already developed a high level of expertise for most terrestrial flora); a complete reference collection of all mangroves known in Vanuatu should be aseembled at the Herbarium. Financial support should also be sought for the development of a National Management Strategy for Mangroves, which is a priority for the DoF. Upgrading FCU capacity regarding mangroves, and development of a national management plan, are particularly important and timely, given the pace of coastal development now being observed in Vanuatu.
- It is important to support, at the national and community level, the introduction of TEK into the formal school curriculum, so as to facilitate transmission and use of TEK by creating greater awareness of its value and applicability in resource management. This could also be facilitated through the introduction of TEK into informal education avenues through rural training centers, and youth, womens and church groups. Village elders of both genders should be included as resource people in curriculum development and as village-level TEK instructors.
- Education materials — including picture booklets of marine and terrestrial resources, which indicate their vernacular names and traditional uses — should be produced to assist with the communities' goals of maintaining their languages and supporting the transmission of TEK

Resource management plan recommendations

By establishing the Amal/Crab Bay Tabu Eria, the communities surrounding Crab Bay have made a significant step in furthering resource management. The biological and social benefits are just now becoming apparent, and communities are reluctant to accept many further restrictions until they see tangible benefits. Given that *Cardisoma* spp. may take three years to reach sexual maturity (see detailed information in the body of the report), it would take at least three years to see an increase in crabs numbers in the area. Consequently, the thrust of the management plan should be strengthening ongoing support for the existing Amal/Crab Bay Tabu Eria.

In addition to agreeing to the closure of the ACTE to resource extraction, a number of villages surrounding the ACTE have initiated village-based management measures focussing on terrestrial, marine and aquatic resources — including land crabs and other important resources — in areas under their tenure. These are locally regulated and overseen by the traditional

leaders of the area, or in some cases by individual landowners/leaseholders. They remain flexible and may be altered, removed, or added to as the communities judge necessary. Many of these resource management initiatives have been recently introduced, and reflect the efforts that IWP has expended in community capacity building and strengthening under this project.

These interventions require further support, particularly after the project finishes in 2006. Thus, it will be useful if local awareness, educational and advocacy materials are produced addressing (i) key issues affecting resource use and management of the ACTE, (ii) other areas of Malekula, and (iii) national level issues.

- Continue to strengthen the ACTE through the production of local awareness materials (video, posters, popular theatre, etc.) as well as educational materials (booklets including vernacular terms and traditional uses) for local schools.
- Encourage and promote the use of TEK to support management of resources, and give practical examples of how TEK can be used.
- Conduct an assessment of the Uri Narong Conservation area to assess management problems, the impact on seawater circulation of what may be excessive mangrove growth, observed benefits, other problems or unexpected results, etc., and thereby take advantage of the lessons that may be learned from a similar, 10-year old resource management initiative.
- Continue to closely monitor both changes in elevation recorded for eastern Malekula/Crab Bay (through new maps, aerial photos and tectonic uplift information from the Department of Geology and Mines), as well as changes in mangal zonation, in order to document changes to the mangal community and associated biota as a result of uplifting. These data will also be useful in monitoring the effects of uplifting on seagrass meadows and corals of Crab Bay's fringing reefs. This information and any mitigative actions and recommendations should be returned to the communities;
- Consider implementing a feral animal eradication effort in Crab Bay. Feral dogs, pigs and cats are now found in Crab Bay. Their predation on crabs, turtle nests and hatchlings, as well as birds and bird nests, may well become a concern in terms of biodiversity management. A constraint to eradication is that additional feral animals are likely to recolonize the Crab Bay from adjacent areas on an ongoing basis. This may require more research to determine the cost/benefits.
- Remove and properly dispose of all rubbish heaps found within the terrestrial area of the ACTE. There are currently two areas within the ACTE that were formerly used (in colonial times) to discard plantation garbage, which included bottles, tins, miscellaneous metal objects as well as batteries and other potentially toxic materials. Any material considered to have historic value (such as old glass bottles or other colonial-era items) could be stored at the ACTE office (under consideration), which is envisaged to also be an interpretive center for visitors, or at the nearby Mapest plantation or Malekula Cultural Centre.
- Remove old engine blocks and other discarded ship remains from the Crab Bay foreshore. Being a busy port in colonial times, derelict ships were left to rot along the foreshore within Crab Bay. All that remains of most of them are their metal parts, primarily their power plant and gearboxes. Many of these are half buried in the sand, are large and heavy and will be difficult to remove. However, the smaller engine parts along the Point could be removed from the beach without much trouble and properly disposed of. Cleaning up the foreshore of discarded engine parts would assist with the long term objective of developing the area for tourism, and would reduce the quantity of toxic materials (heavy metals) in the Crab Bay environment, and the occurrence of ciquaterra in fish populations.

Additional restrictions may be useful to protect the resources targeted in the open areas of Amal/Crab Bay. The following recommendations should be considered if communities and community leaders find it necessary to introduce seasonal gear restrictions, in order to enhance heavily targeted fish stocks during reproductive periods.

- Restrict the use of nets during the annual spawning migrations of Siganids to protect them during this critically important period.
- Restrict the use of nets during the annual spawning migration of mullets (Mugilidae) to protect them during this critically important period.
- Restrict the use of "1 and 2 finger" nets at all times in Crab Bay, or at a minimum, during the hot season, when reproduction is thought to occur.
- Restrict the use of spearfishing at night during the hot months when fish are known to spawn; this would also be useful in protecting species vulnerable to over-harvesting by spearfishers such as the Napoleon wrasse, bumphead parrotfish as well as other Scaridae that typically sleep on reefs at night;
- Restrict trochus harvest openings to short periods (one to two weeks) so that harvested trochus may be easily monitored for size (9 cm is DoF minimum size limit) and quantity (weight) annually harvested. Weights harvested annually should be monitored to document trends.

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Annex 1. Terms of Reference for Marine Ecological Baseline Report

Background

The Vanuatu IWP is working in the area of sustainable coastal fisheries, with secondary activities addressing freshwater quality problems. The project is supporting a community-based pilot project in the Crab Bay area, in Malampa Province on the east coast of the island of Malekula.

The pilot project is intended to promote increased community involvement and responsibility for local resource management and conservation, particularly in the area of community-based fisheries management. If successful the project could provide a model for replication to other coastal communities in Vanuatu. The IWP is also piloting activities at the national level intended to address root cause of environmental issues that cannot be addressed at the local level.

The project is steered by the Vanuatu IWP National Task Force (NTF), which includes representatives from government and non-government organizations. A technical sub committee has been established under the NTF. The day-to-day management of the project is provided by the National Coordinator who is located with the Department of Environment.

Crab Bay Pilot Project

The Crab Bay area is a natural harbour surrounded by mangroves and fringing reefs supporting an array of marine resources. The nine villages in the Crab Bay area participating in the pilot project are: Hatbol, Lingarak, Portindir, Barrick, Loune, New Bush, Bushmans Bay, Tevaliaut, Mapest, Limap, Tebibi, Tarem and Uripiv Island. There is an estimated total population of 1,000 people in the area. The marine resources of Crab Bay provide the local population for subsistence and commercial purposes. There are also three plantations (coconut, cocoa, pepper and vanilla) in the area.

Since selection of Crab Bay communities to host the IWP community-based pilot project in October 2003, a series of activities have been undertaken with the aim of designing a pilot project to address the root causes of fisheries related issues in the Crab Bay area.

A local facilitator training workshop was conducted in April 2004 at the Malampa Provincial headquarters. The workshop provided training to 30 participants to undertake a situation analysis using participatory tools and techniques in each of the villages in the Crab Bay area.

A four-day participatory situation analysis (PSA) consultations with representatives from each of the 9 villages immediately followed the training. Information was collected on priority resource problems, stakeholders, and compilation of village profiles including population, services, village and resource maps, livelihood sources, and village institutions.

The results of the PSA consultations show that the main concerns relating to the decline in various marine resources in the area include: land crab (white), mangroves, reef fish, mud whelk, trochus, clam shell and land crab (black - Caledonia crab), freshwater prawns and surf clam (*kokas*). The land crabs, especially the white crabs, were rated by most villages as the most important resource for subsistence and income. A range of factors were identified contributing to the decline of resources and land crab in particular including:

- uncontrolled harvesting and lack of management controls (e.g. compliance with traditional taboo in the area under the MPA; legislation governing size limits);
- clearance of crab habitat for development and gardens;
- use of destructive gathering methods and their impact on crab and mangrove habitat;
- lack of controls on the sale of crab resources at the local market; and

- lack of information on crab biology and management.

Key stakeholders identified included members of households involved in collecting crab (women, men and youth), women sellers at the Lakatoro market and buyers, notably government employees. The PSA results also highlighted the need to work with the existing MPA established at Crab Bay in 2002 and to develop complimentary and additional actions to support sustainable resource management in the area for which the majority of the area's population rely heavily for subsistence and commercial needs.

In September 2004, the Department of Environment conducted community feedback meetings on the results of the PSA surveys. Other issues discussed during the meetings included next steps for and development of a pilot project management and monitoring plans for Crab Bay area. The outcomes of these meetings included:

- Confirmation of the focus and participation of 5 key villages and settlements for project activities (Bushman Bay Plantation, Tavaliaut and Mapes Plantation, Port Indir, Louni and Barrick community);
- Confirmation that IWP implementation will focus its activities in these five communities on the management of land crabs *(Cardisoma carnifex)* and other key fisheries of relevance to the existing MPA in the area;
- Obtaining community agreements for ecological and socio economic baseline assessments for November-December 2004, involving the participation of community members from these five villages, with the results used to establish management and monitoring plans for fisheries resources in the Crab Bay area, with a focus on land crab resources;
- Agreement for Malampa province through Fisheries and Forestry extension office to assist the community to prepare mapping of the existing MPA boundaries; and
- Request for a local project coordinator to assist the community and fisheries extension officers at the provincial centre in the activites of the pilot project at the community.

The next stage in IWP pilot project implementation involves undertaking socio- economic and ecological baseline assessments during remainder of 2004 and early 2005 to:

- further assess the scale of problems and causes in Crab Bay, particularly in relation to land crabs;
- provide information to assist in identifying solutions and implementation of management and action plans, and
- assist in development of a monitoring plan to be able to assess change over time during IWP.

Objectives

The objectives of the consultancy are to:

Prepare and conduct an ecological baseline survey of the key fisheries resources at Crab Bay in particular land crabs, for the development of a management and monitoring plan, and to support the involvement of the community in baseline assessment and monitoring work.

Scope of work

Working in tandem with the national coordinator IWP Vanuatu, staff of Environment and Fisheries Department, the PCU, and socioeconomic consultant for IWP Vanuatu, the consultant is contracted to undertake related activities outlined below:

Activity: Ecological Baseline Survey

This will involve:

- assessing the ecological status of fisheries in particularly land crab resources at Crab Bay;
- assessing and recommending areas, objectives and strategies for establishing a management plan for the area and land crab resources;
- designing a Monitoring Plan for key indicator species and/or habitats in the area;
- producing a Marine Ecological Baseline Report that will include a Coastal Monitoring Plan for the project in Crab Bay The Coastal Monitoring Plan will be low cost and focussed on community implementation with possible support from Fisheries Department.

Tasks to be performed

The consultant will:

- review relevant existing information on the status of the fisheries in particular land crabs including vegetation and coastal resource maps to include human activities;
- brief and train government staff and local stakeholders as necessary to participate in the ecological assessment work;
- assist the Malampa Fisheries extension officer in mapping of Crab Bay area by preparation of digital maps of the area showing MPA boundaries;
- in consultation with the IWP National Coordinator, local community facilitator, IWP/PCU and socioeconomic consultant coordinate ecological baseline assessment work involving local community participation to assess the ecological status of fisheries in particularly land crab resources at Crab Bay;
- coordinate and undertake the interpretation of the ecological assessment and MPA review and the write up of results (see reports below);
- provide a briefing to the IWP National Task Force on preliminary findings of the ecological assessment survey and MPA review; (including a one page summary);
- in light of the ecological assessment, recommend areas, objectives and strategies for establishing resource management actions, with a focus on land crabs within the authority of each community/Province as appropriate;
- in consultation with the IWP National Coordinator, IWP/PCU and socio-economic consultant design a Monitoring Plan for key indicator species and/or habitats for the area. The monitoring plan will focus on the coastal ecology with identification of key species, proportional coverage and indicator species/habitats that could serve as the basis for future monitoring. The monitoring plan will be low cost and focused on community implementation with possible support from Fisheries Department. It will include a plan for gradual phase out of any external support required to establish it;
- identify training needs for government staff and local stakeholders to undertake the monitoring work and provide training as necessary;
- document work and findings in a Marine Ecological Baseline Report that will include a Monitoring Plan..

Reports

The consultant will be required to produce a Marine Ecological Baseline that clearly describes

the activities undertaken and outcomes of the consultancy. The report will be written in plain English and be submitted in electronic format. It will at least include the following sections:

- review of current coastal ecological information for Crab Bay;
- consultations conducted with government and community stakeholders;
- description of ecological assessment methodologies and activities employed including citations for useful reference material;
- description of any training or briefing sessions undertaken;
- description of stakeholder and community participation in the assessment;
- findings including:
    - ecological profile for the fisheries at the communities (description of current resource/habitat use considerations and issues (related as appropriate to the socioeconomic work undertaken);
    - any constraints or issues encountered;
    - any lessons learned for the IWP;
    - recommendations for resource management
    - identification of appropriate indicator species and/or habitats for future monitoring; and
    - community-based coastal monitoring plan. (This may appear as an annex to the report if appropriate).
- References
- Terms of Reference

Annex 2. People consulted

Includes people consulted throughout the survey, analysis and write-up process. Also included are results of initial consultations with the Management Committee (MC).

Mrs Leah Nimoho, National Coordinator and Ms. Primrose Malalelu, Project Administrative Assistant of IWP, Vanuatu

Mr Trinison Tari, IWP consultant assisting with Participatory Situation Analysis

Mr Wycliffe Bakeo, IWP consultant conducting Participatory Problem Analysis

Mr Moses Amos, Director, Department of Fisheries regarding national Fisheries Department policies on coastal resource management

Mr Robert Jimmy, Principal Fisheries Biologist of the Department of Fisheries (DoF) to discuss the status of their trochus restocking program within Crab Bay

Mr Kalo Pakoa, Principal Officer, Resource Management and Policy Section, DoF to discuss Procfish Survey Protocols and Results for Uripiv area

Mr Sam Channel, (Senior Forest Conservation Officer and Curator of the Herbarium) and Philamon Ala – Assistant Forest Conservation Officer within the Forest Conservation Unit of the Department of Forestry regarding existing flora and mangrove collections and conservation issues from the Crab Bay area; provided expert taxonomic and identification skills regarding botanical samples

Ms Leimon Kalomor, Forest Officer, Forest Conservation Unit regarding Department of Forestry policies and legislation regarding mangroves in Vanuatu

Mr Ralph Regenvanu, Director of Vanuatu Cultural Centre regarding the Vanuatu Cultural Councils national policies on coastal resource management

Mr Selwyn Garu, Secretary of Malvatumauri National Council of Chiefs regarding national traditional leaders policies on coastal resource management

Mr Ernest Bani, Director, Vanuatu Environment Unit, regarding national Environment Unit policies on coastal resource management

Mr Russel Nari, Deputy Director (now Director General of Lands and Environment) regarding national Environment Unit policies on coastal resource management

Mr Douglas Charlie, Department of Geology and Mines regarding tectonic uplift rates in Vanuatu and specific information related to Malekula uplifting

Mr Lino Sanel, Lands Records Office, Department of Lands regarding land titles in the Crab Bay area

Mr Renzly Hambu, Land Use Planning Office regarding mapping information available for Crab Bay as well as map production

Ms Jo Deras, Wan Smolbag Theatre Group, Port Vila, regarding historical coverage of central Malekula to WSBs environmental dramas; also any theatre training provided to date to this area and potential to assist more in this area

Mr George Pedro, Wan Smolbag Theatre Groups Vanua-tai Resource Monitor (VTRM) Network Coordinator to discuss network coverage within the Crab Bay area and any known resource management issues with emphasis on turtles of the Crab Bay area

Dr Kim Friedman of the Secretariat of the Pacific Community (SPC), Procfish Project to discuss Procfish survey protocols and Vanuatu survey results; also confer regarding accessing crab ecology, seagrass and mollusk identification information available through SPC

Dr Mecki Kronen of SPC, Procfish Project regarding Socioeconomic survey results from

Malekula

Mr Japhet Hidson, Forestry Extension Officer, Department of Forestry, Lakatoro, Malekula and member of ACTE MC regarding numerous issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Mr Kevin Mores, Rural Fisheries Development Officer, Department of Fisheries, Lakatoro, Malekula and member of ACTE MC regarding numerous issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Chief Andre Peter, Malekula Council of Chiefs and member of ACTE MC regarding Malekula's traditional leaders policies on coastal resource management

Mr Graham Willy, MALAMPA Provincial Government Project Officer and ACTE MC member regarding Provincial Government policies and support for resource management initiatives within MALAMPA Province

Mr Roy Matariki, IWP Interim Local Facilitator assisting Crab Bay communities in the strengthening of the ACTE regarding numerous issues relating to the ACTE and the development of a monitoring plan and management plan recommendations

Mr James Fatial Bangsuh, a knowledgeable elder member of Limap village that had been traditionally ordained as a leader regarding the traditional use of resources in Crab Bay and other local customary practices and beliefs

Mr Frank Kenneth, a knowledgeable elder, local historian and vernacular expert from Uripiv Island regarding the traditional use of resources in the Crab Bay area and for clarification of vernacular terms of various resources

Mr Numa Fred, Malekula Cultural Centre Curator from Uripiv Island regarding traditional use of resources in the Crab Bay area as well as assistance with clarifying vernacular terms of fish

Mrs Selene, a CF of Port Indir regarding traditional and contemporary women's fisheries including for land crabs as well the traditional knowledge associated with these fisheries and monitoring and management plan recommendations

Mrs Lekolan of Port Indir, an elderly crab fisher and regular seller in the market regarding traditional and contemporary knowledge associated with land crabs

Chief Manoa Kaun, Chief of Leoni village, CF and member of ACTE MC regarding numerous issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Chief Graham James, Chief of Limap village, CF and member of ACTE MC regarding numerous issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Chief William Muramor, Chief of Port Indir village, CF and member of ACTE MC regarding vernacular terms and traditional use of resources as well numerous other issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Chief Pedrid John, Chief of Uri Village, CF and member of ACTE MC regarding Uri mangrove management area initiative as well as numerous issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Mr Spetly Johna CF of Hatbol village and member of ACTE MC regarding numerous issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Mr Lency Kaun, CF for Leoni village and assistant to the DoF trochus program in Crab Bay regarding trochus enhancement strategies numerous issues related to the ACTE including the

development of a monitoring plan and management plan recommendations

Mr Edwin Pitae, Manager of MAPEST Plantation and ACTE MC member regarding numerous issues related to the ACTE including the development of a monitoring plan and management plan recommendations

Mr Kalmari Noel of Baddik village a CF regarding contemporary fishing areas and practices within Crab Bay area as well as the development of a monitoring plan and management plan recommendations

Mr Johnlyn, VTRM from Uripiv Island regarding use of turtle resources and turtle management in the Uripiv area

On arrival to Crab Bay on November 24th an all afternoon meeting was held with the Rural Fisheries Development Officer (RFDO) and interim Community Facilitator. This gave an opportunity to visit the Amal side of the MPA and discuss the agenda for the Management Committee (MC) meeting the following day as well as go over the Work Plan for the following two weeks.

An all day meeting was held November 25 with the MC of the MPA known locally as the Amal/Crab Bay Tabu Eria (ACTE). This name was chosen to maintain cultural appropriateness for the entire spectrum of community members, from the elders to young children. During this meeting the consultant provided information on the life cycle of the white crab (*Cardisoma carnifex*) to the MC while the MC provided aspects of their traditional knowledge (TK) of the crab lifecycle. Other main points discussed included examples of various resource management initiatives found from different parts of Vanuatu, the value of drawing upon traditional resource management methods and traditional knowledge in management as well as gaining input from the MCs on a resource management and monitoring plan.

Examples of how traditional knowledge may be used for management purposes were provided. Some examples of these are given below;

Knowing when and where fish migrate for spawning purposes, (in the Crab Bay area this is especially relevant for Rabbit Fish or mullet as it is ideal habitat for them) such that, for example, nets could be banned when these fish are known to undertake their spawning migration along the coast in order to protect them during this important time. Once spawning is completed, the use of nets may again be allowed; also, knowing the location of their spawning aggregation could allow for a taboo on fishing to be placed at this location until the spawning period is completed in order to protect them at the site of their aggregation from spearfishermen, for example

Similarly, knowing the reproductive period of land crabs that are dependant on the Crab Bay habitats can assist for management purposes by restricting harvesting during this period, to say males only, or for subsistence only (ie, not for commercial harvests, ie sale in the local market) or completely restricting harvesting of all crabs during this period in some areas particularly important to the crabs, if it is felt that the resource has declined so much as to warrant this. Again, knowing where the crabs migrate to in order to release their eggs into the sea can mean that these coastal locations can be put under taboo during this period in order to protect them

Knowing where and when turtles come ashore to nest means people can avoid lighting fires or creating disturbances in the area during these periods to allow the turtles to successfully nest in these areas. As turtles are important for subsistence in this area, allowing turtles to successfully nest has obvious management value to ensure adequate subsistence catches.

Knowing and using the vernacular names of various resources is also important in that the name often contains valuable ecological knowledge associated with the resource, ie, it alludes to its habitat, or some other feature of the resource. It is becoming increasingly important to maintain the linguistic diversity of the Pacific as many languages are now being lost, and with it the ecological knowledge contained therein.

Knowing the importance of mangroves as fish, terrestrial and mangrove crab and shellfish habitat, especially for many species of juvenile fish (like snappers) important as food fish means that people are less inclined to cut large areas of mangroves for firewood, as house posts or other purposes.

Additional issues discussed included what methods and what level of resource monitoring would be appropriate and sustainable for the communities to monitor changes within the ACTE with the assistance of RFDO.

Annex 3. Botanical transect species lists

Note: All species indicated with an asterisk are endemic to Vanuatu.

Annex 3.1. AMAL Flora Survey Transect Results

Amal Transect 1	**Amal Transect 2**	**Amal Transect 3**
Start:	Start:	Start:
16 09.448 S, 167.30.691 E	16 09.567 S, 167.30.842 E	16 09.545 S, 167 30.842 E
End: 16 09.527 S, 167 30.734 E		
Site Description: follows western border of Amal taboo area	Site Description: starts at mudflat & heads south 80 m	Site Description: starts at mudflat & heads north 80 m
Date Sampled: 30/11/05	Date Sampled: 04/12/04	Date Sampled: 04/12/04
Avicennia marina	*Excoecaria agallocha*	*Excoecaria agallocha*
Rhizophora stylosa	*Caesalpinia crista*	*Thespesia populnea*
R. mucronata	*Thespesia populnea*	*Ceasalpinia crista*
Sonneratia alba	*Ellattostachys falcata*	*Derris trifoliata*
S. caseolaria?	*Malaysia scandens*	*Acacia spirobis*
Ceriops tagal	*Pouteria costata*	*Dysoxylum bijugum*
Derris trifoliata	*Mimusops elengi*	*Pouteria costata*
Xylocarpus molucensis	*Murraya paniculata*	*Murraya paniculata*
X. granatum	*Dysoxylum bijugum*	*Elattostachys falcata*
Caesalpinia crista	*Bleigenium timoriensis*	*Pandanus tectorius*
Cordia subcordata	*Acacia spirobis*	*Glochidion perakense*
Thespesia populnea	*Neisosperma oppositifolia*	*Cordia subcordata*
Caesalpinia bonduc	*Instia bijuga*	*Mimusops elengi*
Cocos nucifera	*Gardenia tannaensis* *	*Gyrocarpus americanus*
Pandanus tectorius	*Macaranga tanarius*	*Psychotria forsteriana*
Guetardia speciosa	*Dysoxylum gaudichaudianum*	*Garuga floribunda*
Instia bijuga	*Heritiera littoralis*	*Guettarda speciosa*
Acacia spirobis	*Gyrocarpus americanus*	*Macaranga tanarius*
Macaranga tanarius	*Pandanus tectorius*	*Ervatamia obtusciuscula*
Murraya paniculata	*Merremia* sp.	*Claoxylon fallax*
Gyrocarpus americanus	*Terminalia samoensis*	
Prema corymbosa		
Elattostachys falcate		
Heritiera littoralis		
Terminalia samoensis		
Ficus glandifera		
Glochidion ramiflorun		

Annex 3.2. Crab Bay flora survey transect results

Transect 1	**Transect 2**	**Transect 3**
Position:	Position:	Position:
16 09.754 S, 167 32.478 E	16 09.917 S, 167 32.689 E	16 10.207 S, 167 32.851 E
running inland from beach 80 m to access road	running inland 280 m from beach across access road	running inland 140 m from beach & across access road
Site Description: small lane leading to *R. stylosa* thicket (MCBT4)	Site Description: small lane from "Trochus Site" to road and inland for another 200 m	Site Description: located at "Graham's house" starting at beach
Date/Time Sampled: 01/12/04 1400 h	Date/Time Sampled: 02/12/04 1400 h	Date/Time Sampled: 07/12/04 1400 h
Avicennia marina	*R. stylosa*	*Thuarea involuta*
Rhizophora stylosa	*Thuarea involuta*	*Hibiscus tiliaceus*
Thuarea involuta	*M. argentea*	*H. nymphaeifolia*
Messerschmidia argentea	*A. simplex*	*Acacia simplex*
Scaevola taccada	*Pandanus* sp.	*Derris trifoliata*
Prema corymbosa	*Cassia obtusifolia*	*Desmodium umbelatum*
Vitex trifolia	*H. nymphaepholia*	*Hallophyllus cobbe*
Morinda citrifolia	*B. asiatica*	*P. tectorius*
Carica papaya	*A. spirobis*	*Barringtonia asiatica*
Ryssopteris timoriensis	*M. citrifolia*	*E. agallocha*
Derris trifoliata	*Claoxylon fallax*	*Acacia spirobis*
Neisosperma oppisitifolia	*D. trifoliate*	*Neisosperma oppisitifolia*
Indogofera fruiticosa	*G. speciosa*	*Instia bijuga*
Acacia spirobis	*Hallophyllus sp.*	*Caesalpinia crista*
Pandanus tectorius.	*C. inophylum*	*Glochidion perakense **
Causarina equisifolia	*P. corymbosa*	*Tarenna sambucina*
Hallophyllus cobbe	*Grewia molococca*	*Colubrina asiatica*
Excoecaria agallocha	*Ixora triflora **	*Macaranga tanarius*
Claoxylon fallax	*M. paniculata*	*Claoxylon fallax*
Colubrina asciatica	*C. bonduc*	*Ervatamia obtuciuscula*
Malaysia scandens	*Pouteria costata*	*Dysoxylum bijugum*
Grewia malococca	*N. oppisitifolia*	*Cordia subcordata*
Murraya paniculata	*Ervatamia obtusciuscula*	
Hernandia nymphaeifolia	*E. allogada*	
Ficus sp.	*H. tiliaceus*	
Elattostachys falcate	*Mimusops elengi*	
Leucaena leucocephala	*G. ramiflorum*	
Terminalia samoensis	*Soulamea amara*	
Trema orientalis	*Tylophora aneityensis**	
	Traverse Crab Bay Road	
	H. tiliaceus	
	S. amara	
	Hallophyllus cobbe	
	H. nymphaeifolia	
	Acacia spirobis	
	Terminalia samoensis	
	Pandanus tectorius	

Caesalpinia crista.
Cordia subcordata
Heritiera littoralis
Dysoxylum bijugum
Tarenna sambucina
E. obtusciuscula
Minusops elengi
Morinda citrifolia
A. pavonina
Ficus sp.
Derris trifoliate
Breynia disticha
Indigofera fruiticosa
G. malococca
Instia bijuga
*Glochidion perakense **
Diospyros samoensis
Trema orientalis
Psychotria forsteriana
Guettarda speciosa
G. americanus

Annex 4. Vernacular terms and traditional uses of terrestrial flora found in the ACTE

Scientific names	Uripiv	Lingarakh	Hatbol
Acacia simplex	Mari	nimaribal	maribal
Acacia spirobis	Maribil	nimari	mari
Barringtonia asiatica	nu-amp	nimblus tabo	Ewen
Caesalpinia bonduc	Moku	noghomgha	Maka
Calophyllum inophylum	Baur	nimbaghur	bagur
Claoxylon fallax	nai-ej	naghaghinch	yio
Cordia subcordata	Jeli	Nibalgha tusu	Balaga nan tuswe
Derris trifoliata	Natu	noghotuv	Atuv
Ervatamia obtusciuscula	Jal	ninjalmas	cecil tamat
Excoecaria agallocha	Natot	nimlogjok	etet
Glochidion ramiflorum	Ngi room	nimla	mala
Grewia molococca	Jerau	nisarap	sarap
Guettarda speciosa	Naumpr	nemagh	
Gyrocarpus americanus	Ndrau	nidiaef	dwef
Hallophyllus coppe	Dokonwut	noghotvurghoyel	Arambru kokoyar
Hernandia nymphaepholia	Birbir	nibirbir	birbir
Hibiscus tiliaceus	Vava	nimbalgha	balaga
Indigofera fruticosa	Ngarim	Naghavinmeme	Yadram
Instia bijuga	Nator	nuguma	uma
Ixora triflora	Nira	Nisighat	Aramramad
Macaranga tanarius	Naunu	Nivenue	Ibnu
Malaysia scandens	Garjulu	Nogho barmus	Bamu
Messerschmidia argentea	Dengir	nitamamlef	molova yopyup
Mimusops elengi	Nambot	nombunych	ombo
Morinda citrifolia	Naur	naghur	Vini-raur
Murraya paniculata	Luk	Nemarlang	Marlang
Neisosperma oppisitifolia	Bivarvar	Numblus Yofyo	Arup
Pandanus tectorius.	Weibur	ndrum	Biripmusmus
Pouteria costata	Nurwit	Nurap	aruplam
Premna corymbosa	Nirabol	nirbal	Bobbob
Scaevola taccada			
Soulamea amara	Nemenbai	Narub	elam
Terminalia somoensis			
Thuarea involuta	Musmus	nibatigsiriou	mana
Tylophora aneityensis	Naiweng	noghovat	Tilia
Adenanthera pavonina	Wunwun	Nibisbis	Bisbis

Annex 5. Traditional uses for mangrove types found in the ACTE

Every true mangrove contains a red/brown dye in its bark. Many also have medicinal uses, but these were not documented in consideration of intellectual property rights issues.

1) **Namur** — (***Sonneratia caseolaria/alba***) Round leaf, fruit shape ovoid; pnuematophores;

Etym: unknown

Uses; canoe hulls cut from trunk; the pnuematophores are use as corks for bottles. Flying foxes (both white and black) eat the ripened fruits. Birds like *wila jumerel* and *wila jumperev* consume the flower nectar. The buttress roots serve as hiding places for crabs.

2) Ndrongminmin — (***R. mucronata***) Tall trees with large leaves growing in areas with freshwater influence. Large, strong prop roots.

Etym: "drinking mangrove" (i.e. a mangrove that drinks a lot of water).

Uses: Is a strong house and fence posts and good firewood. May also be used to make bows. Birds like *wila jumerel* and *wila jumperev* and flying foxes consume the flowers nectar. Crabs hide and rest amongst the prop roots.

3) Ndrongneves — (***R. stylosa***) Small leaves with long hanging fruits; a dominant species with extensive prop roots.

Etym: "Bow Mangrove" — Bending mangrove (or mangrove that bends).

Uses: Commonly used for making bows and is used for firewood. Strips of pith in young prop roots can be used as cordage. Does not make very good house posts as it doesn't grow very straight. Creates excellent habitat for crabs to hide amongst. And is a nursery area for mullet, rabbit fish, emperors and mangrove snappers. Shellfish common amongst their prop roots like banu, dirong, serwok, etc. and oysters found attached to prop roots.

4) Ndrongrat — (***R. apiculata*?**) Large leaves, prop roots and growth form similar to ndrongneves, but flowers and leaves similar to ndrongminmin. Fruits shorter than ndrongneves. Not common but may be found in association with ndrongneves. Is not found in large groups.

Etym: "Indicator mangrove" as when it fruits this foretells the coming of a cyclone (rat = cyclone).

Uses: same as ndrongneves.

5) Ndrongnaim — alternate name — **Ndrongress** (possibly the older name) — (***Ceriops tagal***) – small leaves, straight and tall bole; long ribbed fruits.

Etym: "mangrove that grows straight" or "post-like mangrove"

Uses: It is the preferred mangrove to use as a house post due to its durable, long straight bole; is also excellent for beams and rafters.

Is used as a seasonal (December–March) sleeping and feeding area for flying foxes (especially *Pteropus aneitanus*) as it grows straight and tall (thereby creating suitable hanging sites) as well as juvenile *P. tonganus*. Larger trees have buttressed roots creating good crab habitat. The fern (*Nembre - Acrostichum*) grows in association with Ndrongnaim, also creating good crab habitat.

6) Naviv — (***Avicennia marina***) Leaves small and yellowish; pnuematophores. Grows along seaward edge of mangles. Larger trees are also found growing inland (most likely due to uplifting effects). Small mango shaped fruits. Fast growing and dominating the coast where the seawater is clear.

Etym: meaning a dominating mangrove; dislikes other species

Uses: Is an excellent firewood, even when wet ("waterproof firewood"). Mainly grows along low water seaward fringe thus creating excellent fish habitat amongst pnuematophores. Is also found scattered in small groups over Amal fringe reef far from land. Birds use this tree to roost in (eg. Short leg and White Eye). Giant clams (Hippopus hippopus) also found amongst its pnuematophores and black and white sea snake hides in stump holes.

7) Noar — *Xylocarpus granatum* – (puzzle fruit)

Etym: Tree similar to Nur (a tree with apple-like edible fruit)

Uses: Firewood, houseposts and the fruit is used by children as a puzzle-toy.

8) Naelaslas — *Xylocarpus molucuensis*

Etym: large testicles (it was tabu to touch this fruit as it could result in a malade known as bigball (Filiarisis).

Uses: Firewood, houseposts and the fruit is used as a children's puzzle-toy.

9) Natot — *Excoecaria agallocha*

Etym: A weak wood with white latex; easily broken.

Uses: firewood, latex can be used as a glue as well as a medicine for sore teeth. Flower indicates the season when land crabs are fat.

Annex 6: Crab Bay avifauna vernacular terms

Common Name/Bislama	Uripiv	Lingarak	Hatbol	Scientific Name	English
Bird	Numen	Niman			
Hawk (brown)	Nimbel lolmaruel	Nimbalyas	Abal metmet	*Acipiter fasciatus*	Brown (Australian) Goshawk
Wild Duck	Duk Duk	Dukduk	Duk duk	*Anas superciliosa*	Pacific Black Duck
Reef Heron (white)	Tetetaniuf	Nimanlambyofyof	Paulyepyepyopyop	*Ardea sacra*	Eastern Reef Heron (White morph)
Reef Heron	Mericalo	Niman lamb	Paulyepyep	*Ardea sacra*	Eastern Reef Heron
Woodswallow	Tasinbel	Balyasyas	Selaman	*Artamus leucorhynchus*	White-breasted Woodswallow
Mangrove Bird	Berbernarong	Man Bit dong		*Butorides striatus?*	Little (Mangrove) Heron
Dove (short leg)	Umer	Nimar	Abmar	*Chalcophaps indica*	Green-winged Ground Dove
Hawk (bigfala)	Nimbel	Nimbal	Abal	*Circus approximans*	Swamp Harrier
Swiftlet	Kerkeryal	Nimghomg Homyal	Bobomial	*Collocalia esculenta*	White Bellied Swiftlet
Nataro	Daro	Notdro	Dtoro	*Columba vitiensis*	White-throated Pigeon
Nawimba	Nimb	Nughumb	Wim	*Dacula pacifica*	Dove
Shorebird	Bilbildrong			*Esacus magnirostris*	Beach Thick-knee
Pidjin blong huriken	Mendus	Niman lang rap	Abal yeye	*Fregata* spp.	Frigate Bird
Nambilak	Billa	Nimbilaghbisbis	Vilavinbis	*Gallirallus philippensis*	Rail
Wild Fowl	Natodorum	Nototetur	Oto matak	*Gallus gallus*	Red Jungle Fowl
Champion Bird	Wila ne danlep	Levatvat	Levin	*Rhipidura spilodera*	Spotted Fantail
Nasiko	Nasi	Nasik	Asik	*Halcyon chloris*	King Fisher (white chest)
Nasiko (braon)	Nasi	Nasiktlolghuan	Asi ambr	*Halcyon farquhari*	King Fisher (brown chest)
Wandering Tatler	Neber			*Heteroscelus incanus*	Wandering Tatler
Kuskus (small)	Wilajunperif	Levitrasup	Levilak	*Lichmera incana*	Silver eared Honeyeater
Longtail	Wetov	Lemalta	Lepmilda	*Macropygia mackinlayi*	Rufous Brown Pheasant Dove
Namalau	Molu	Notomla	Otomala	*Megapodius freycinet layardi*	Megapode, Scrub Duck
Red Head	Siwir Buegn	Nimanbongmial	Burubith	*Myzomela cardinalis*	Cardinal Honeyeater

Common Name/Bislama	Uripiv	Lingarak	Hatbol	Scientific Name	English
Whimbrel	Weir	Nimbilak vatgha vic		*Numenius phaeopus*	Whimbrel
Kuskus big (10 tongue)	Lala ?	Neverula	Verula	*Phylidonyris notabalis **	Vanuatu Mountain (White Bellied) Honeyeater
Green Pigeon (red chest)	Shengra	Nivebur'n bong	Nebrun	*Ptilinopus greyii*	Red Bellied Dove
Green Pigeon (small)	Gaum	Nivebur'n merse	Nebrun Merse	*Ptilinopus greyii (inmature)*	Red Bellied Dove inmature plumage
Green Pigeon (large)	Menbe	Nivingam	Vinkaum	*Ptilinopus tannensis*	Vanuatu (Yellow-headed) Fruit Dove
Nasiviru	Siwir	Nisbur	Sivir	*Trichoglossus haematodus*	Rainbow Lorikeet
Champion (short mouth)	Newis mambur	Legragras	Levin batavat	*Turdus poliocephalus*	Island Thrush
Naet Hawk	Nubur	Nitarban	Tarban	*Tyto alba*	Barn Owl
White Eye	Metmetwila	Nivelagh	Levilak	*Zosterops flavifrons*	Vanuatu (Yellow) White Eye
Waet eye (Big)	Wilajum morol	Nivelaghbuas		*Zosterops lateralis*	Grey-backed Whiteye
Big Head	Metwis	Lemetvannias	Iliau		

Annex 7: Crab Bay Mammal vernacular terms

Common Name	Species	Uripiv	Lingarak	Hatbol
Wild Dog	*Canis* spp.	Gulie room	Nagham bir tetur	Ghambir matak
Wild Cat	*Felis* spp.	Pusi room	Bisbough aham bir	Busubok tamat
Wild Pig	*Sus* spp.	Berver room	Nibarbar tetur	Bala matak
Mice	*Mus* spp.	Narif	Bisbogh vansal	Busubok Vinyesal
Rat	*Rattus* spp.	Narif	Nimbis bogh	Busubok
Black Flying Fox	*Pteropus tonganus*	Kerimot	Nitambrasmetmet	Minikara
White Flying Fox	*Pteropus anetianus* *	Kerilewet	Lemang	Levis
Small Bat (with tail)	*Notopteris macdonaldi?**	Kerinarif	Nitambras bis bogh	Vusumaririk
Mangrove Flying Fox **	*Pteropus fundatus?? **	Kerinarong	Nitambras dong	Makamilbir

*endemic species; ** possible that this bat is a juvenile P. tonganus

Annex 8: Land Crabs of Crab Bay Survey Results

Annex 8.1: Crab burrow density

AMAL and vicinity

Quadrant #	ACD1	ACD2	ACD3	ACD4	ACD5	ACD6	Total	Mean
Date	04/12/04	04/12/04	04/12/04	04/12/04	04/12/04	04/12/04		ACD1-ACD6
area (m^2)	100	100	100	100	100	100		
# of holes	38	159	42	101	79	40		
crabs/m^2	0.38	1.59	0.42	1.01	0.79	0.4	4.59	0.765 (n=6)
Site description	16.09.564 S 167 30.949 E HWM of mangroves	50-m south of Q 4 -CF >trees & shade > litter	N. of desert mangroves	N of Desert; E of 3 "Wait a Bit"	forest off road near desert	6-m east of access road		

Quadrant #	ACD7	Total & Mean
	3	ACD7
Date	05/12/04	
Total/100 m^2	205	
crabs/m^2	2.05	2.05 (n=1)
Site description	16 09.828 S 167 30.396 E Plantation-out of Amal	

Crab Bay

Quadrant #	CBCD1	CBCD2	CBCD3	CBCD4	CBCD5	CBCD6	CBCD7	CBCD8
Date	6/12/2004	6/12/2004	6/12/2004	6/12/2004	7/12/2004	7/12/2004	7/12/2004	7/12/2004
area (m^2)	100	100	100	100	100	100	100	100
# of holes	9	39	203	91	12	287	107	85
crabs/m^2	0.09	0.39	2.03	0.91	0.12	2.87	1.07	0.85
Site description	main gate bush	open area	burao	coconut plantation near fence	seacoast near road burao/pand	mangrove desert	above? desert	inland mangrove associates
Quadrant #	**CBCD9**	**CBCD10**	**CBCD11**	**CBCD12**	**CBCD13**	**CBCD14**	**CBCD15**	**CBCD16**
Date	Dec.8/04	Dec.8/04	Dec.8/04	Dec.8/04	2/2/2005	2/2/2005	2/2/2005	2/2/2005
area (m^2)	100	100	100	100	100	100	100	100
# of holes	3	13	105	12	36	21	72	86
crabs/m^2	0.03	0.13	1.05	0.12	0.36	0.21	0.72	0.86
Site description	seaside above HW	inland shade	between mangroves & bush	Crab Pt. grassy area	desert N of boundary	seaside forest	W of road LF	W of road N of CD 15
Quadrant #	**CBCD17**	**CBCD18**					**Mean**	
Date	2/2/2005	2/2/2005					CBCD1-CBCD18	
area (m^2)	100	100						
# of holes	45	105						
crabs/m^2	0.45	1.05					0.74 burrows/m^2	
Site Description	E of road, seaside forest	mangroves W of road						

Outside of ACTE

Quadrant #	CBCD19	CBCD20	CBCD21	CBCD22	Mean & Total		Village Sites				Mean & Total	
							L1	L2	Lim-1	Lim-2		
Date	3/2/2005	3/2/2005	26/05/05	26/05/05	(CBCD19-CBCD22)		30/05/05	30/05/05	30/05/05	30/05/05	(L1-L2; Lim1-Lim2)	
Area	100	100	100	100			100	100	100	100		
# of holes	31	83	85	14	**Total**	**Mean**	142	124	15	27	**Total**	**Mean**
crabs/m^2	0.31	0.83	.85	.14.	**2.13**	**0.53**	1.42	1.24	.15	.27	**3.08**	**.77**
Site Description	Seaside, outside ACTE (Mapest Plantation)	Mapest, outside ACTE (in burao)	Seaside, outside ACTE (All small holes)	Logged outside ACTE (Mostly small holes)			Leone Lawrence plantation (92 small holes)	Leone above passage (118 small holes)	Limap Garden-all (Black crabs)	Limap Coastal-Freddy (Mostly white crabs)		

Annex 8.2: Baited Crab count results

Crab Bay (Soak Time for Baits = 1 Hr.)

General area: trochus site	**16° 09.932' S, 167° 32.667' E**	**Note: original trials to develop and refine the technique**							
Date	3/12/2004								
Trial		#1	#2	#3				Total	Mean
Station #		trial1	trial2	trial3					
# of crabs		60	80	90				230	76.7
Time checked		1447	1547	1647					
habitat type		CF	CF	CF					
Weather	Dry								
Comments	CF = Coastal Forest								
General area: Southern Boundary									
Date	6/12/2004								
Trial		#1	#2	#3	#4	#5	#6	Total	Mean
Station #		BC1	BC2	BC3	BC4	BC5	BC6		

# of crabs		1	2	3	1	0	22	29	4.8
Time checked		1245	1300	1315	1330	1405	1411		
habitat type		scrubby bush	desert	mangroves	LF	roadside	CF		
Weather	Dry		fringe						
Comments	sunny hot day; too dry @ midday - #6 close to sea-breeze in good shade & later in day								
	LF=Lowland forest								
General area: Southern CB along road									
Date	7/12/2004								
Trial		#1	#2	#3	#4	#5		Total	Mean
Station #		BC7	BC8	BC9	BC10	BC11			
# of crabs		4	22	24	24	23		97	19.4
Time checked		1400	1410	1420	1430	1440			
habitat type		CF	SSF	CF	SSF	CF			
Weather	Dry								
Comments	presumed to be too hot								
General area: Northern CB									
Date	8/12/2004								
Trial		#1	#2	#3				Total	Mean
Station #		BC12	BC13	BC14					
# of crabs		40	30	185				255	85
Time checked		1500	1515	1530					
habitat type		SSF	CF	SSF					
Weather	Dry								
comments	highest station (BC14) from seaside and latest time								
General area: Entire CB									
Date	2/2/2005								
Trial		#1	#2	#3	#4	#5	#6	Total	Mean
Station #		BC15	BC16	BC17	BC18	BC19	BC20		
# of crabs		11	51	40	13	79	25	219	36.5
Time		1355	1410	1415	1220	1600	1617		

checked							
habitat type		mangrove/desert	SSF	SSF	CF	mangrove	mangrove
Weather	Wet/humid						
comments		1 B/C					
General area: Mapest Plantation open area							
Date	03//02/05						
Trial		1	2	Total	Mean		
Station #		BC21	BC22				
# of crabs		19	57	76	38		
Time checked		945	1000				
habitat type		SSF	Burao				
Weather	Wet/humid						
Comments/ key		2 Black Crab (B/C)	1 B/C	SSF= seaside forest	CF = coastal forest		

AMAL Baited Crab Counts

General area: NW of desert area; 16 09.564 S, 167 30.949 E							
Date	4/12/2004						
Site		ABC1	ABC2	ABC3		Total	Mean
# of crabs		4	10	21		35	11.7
Time checked		1630	1640	1650			
habitat type		CF	>HWM	mangroves			
Weather	Dry						
comments							
General area: throughout Amal							
Date	3/2/2005						
Site		ABC1	ABC2	ABC4	ABC5	Total	Mean
# of crabs		4	8	6	5	23	5.75
Time checked		1445	1515	1625	1700		
habitat type		mangrove	mangrove	LF	Burao		

Weather	Wet			thicket
comments			some BC	some BC
	BC = black crab	LF=lowland	forest	

Annex 8.3. Timed Crab Counts

Crab Bay/Amal

Area: Crab Bay Date: 6/12/2004										
Interval	**1**	**2**	**3**	**4**	**5**	**6**	**Total**	**Mean**		Dry Season Mean
Crab Counts	21	108	80	62			271	67.75		61
time	1400	1540	1550	1600						
Weather	partial sun/dry									
Comments										
Area: Crab Bay Date: 7/12/04										
Interval	**1**	**2**	**3**	**4**	**5**	**6**	**Total**	**Mean**		
Crab Counts	25	56	110	19	250		460	92		
time	1450	1505	1515	1530	1700					
Weather	partial sun/dry									
Comments										
Area: Crab Bay Date: 8/12/04										
Interval	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**	**Mean**
Crab Counts	13	32	38	11	22	19	44	5	184	23
time	1605	1612	1617	1622	1627	1632	1637	1642		
Weather	sunny/dry									
Comments	very hot and dry									
Area: Crab Bay Date: 2/2/2005										
Interval	**1**	**2**	**3**	**4**	**5**	**6**	**Total**	**Mean**		
Crab Counts	139	144	112	97	87	18	597	99.5	WET SEASON	100
time	1430	1445	1500	1515	1525	1535				
Weather	wet									
Comments	some black crabs observed									
Area: Crab Bay- Mapest Plantation outside the ACTE Date: 3/2/2005										

Interval	1	2									
Crab Counts	51	63	114	57							57
time	840	920									
Weather	wet										
Comments	some black crabs observed										
Area: AMAL SIDE Date: 3/2/2005											
Interval	1	2	3	4	5	6	Total	Mean			
Crab Counts	43	6					49	24.5		AMAL	25
time	1430	1445									
Weather	wet										
Comments	some BC										

Annex 9: Finfish survey sites for Amal and Crab Bay

Amal

MAT1: in the SE wind exposed Amal fringe reef with some seagrass, coral rubble and pavement substrate but with a large stone making the habitat more diverse as well as easily identifiable; a 6–7-m diameter circle was surveyed around this stone in addition to the immediate area further from the stone for comparison;

MAT2: large stand of *R. stylosa* found growing amongst seagrass over the Amal fringe reef; there are numerous small groupings of *A. marina* growing nearby; this thicket was surveyed by snorkeling around and through the entire thicket

MAT3: is the DOF trochus control site and therefore easily identifiable to CFs; it is a turbulent area where the fringe reef drops-off to deeper water and is characterized by spur and groove formations with 60–70% coral coverage with numerous 'swim through' and small caves dropping off to sand substrate; this site was also found to have a significant freshwater lens at the surface and generally had poor visibility;

MAT4: is a very exposed fringe reef drop-off that may not be easily sampled without scuba during trade wind season; this area was sampled by snorkeling during early Feb. 2005 when light westerly winds allowed access and was found to have some freshwater springs and a zooplankton bloom;

Crab Bay

Crab Bay has a total of 8 sites, with 2 of them being in the middle of the bay where fishing is allowed as indicated in Figure 1 and are described as follows.

MCBT1: the fringe reef drop off just north of Crab Bay Point; this site has poor visibility, with limited coral cover but with a good diversity of smaller reef fishes;

MCBT2: the north-western tip of the Crab Bay fringe reef drop off with similar conditions to MCBT1

MCBT3: is the DOF trochus experimental site and so in easily locatable by CFs for re-sampling; this area of predominantly coral pavement is very exposed with strong, turbulent tidal flows;

MCBT4: is a large thicket of mature *R. stylosa* extending from the sand beach to seagrass beds and includes deep pools around its base; this complex of prop roots provides habitat for a diversity of fishes;

MCBT5: is a large monospecific thicket of *A. marina* immediately west of MCBT4 and paralleling the beach for some 300-m; large freshwater influences, presumably through seepage, observed here;

MCBT6: is a sprawling thicket of primarily ***R. stylosa*** forming a small island within Crab Bay over sand and amongst seagrasses; this area is open to fishing

MCBT7: is a similar thicket to MCBT7 further northwest with a few large *Sonneratia* mangroves; this area is also open to fishing;

MCBT8: is on the exposed side of Crab Bay fringe-reef drop off that will also be difficult to sample during trade winds season without the use of scuba;

The position of these fish sample transects as recorded by GPS are given on the data sheets appearing in Annex 10, along with more detailed site descriptions and survey results.

Annex 10. Crab Bay Finfish Survey Results

Transect designations are as follows; M = Marine Sites; A= Amal; 1 or 2 refers to the two different sampling periods – 1 was between Dec.6 & 9/04; 2 was between Feb.2-3/05; T1 – T-4 refers to individual transect numbers; if a given transect was sampled twice in the same period it is designated as TX-X-2.

These sites are all shown in Figure 3 indicating the location of Marine Sampling Sites. The designation on the map however exclude the 1 or 2 associated with the time of sampling, eg, they would indicate MAT1, not MA1-T1.

AMAL Results

MA1-T1

Marine Resource Baseline Survey of Crab Bay/Amal

Location: AMAL				
Name of Area: Eastern Pt - 5-m radius around large stone @ 16 09.315 S; 167 31.691 E				
Date: DEC. 7/04	1230 h			
Habitat Type	coral pavement/rubble/seagrass; <10% coral cover			
limited fish diversity	limited visibility - wind 15 knots - exposed & strong tide/current			
TRANSECT #	**MA1-T1**	cyclone damage incl. loss of seagrass		
TURTLES			**REL.**	
FISH			**ABUND.**	
LOCHE	MBWETY	Groupers	S	Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae

CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrot fish		Scaridae
RED MAOT	MENGA	Emperors - *L. harak*	P	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma			M	Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	*L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.		Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	P	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.	P	Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish	P	Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	P	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels	P	Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp – 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents	P	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			
BECH-DE-MER	NOJINAVUL			

LOLLY FIS			M	
GREEN FIS				
BLACKTIT			S	
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugong dugon*		Mammalia
TURTLES	NEWU			Reptilia

MA2-T1

Marine Resource Baseline Survey of Crab Bay/Amal

Location: AMAL

Name of Area:Eastern Pt - 5-m radius around stone 16 09.315 S; 167 31.691 E

Date: Feb.2/05	1200 h	Ebbing tide		
Habitat Type	coral pavement/rubble/seagrass; <10 % live coral cover			
limited fish diversity	reasonable visibility - wind lite westerly- sea calm			
some cyclone damage evident incl. loss of seagrass in general area				
TRANSECT #	**MA2-T1**		**REL. ABUND.**	
FISH				
LOCHE	MBWETY	Groupers	S	Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish	P	Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	S	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish	S	Scaridae

RED MAOT	MENGA	Emperors	S	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	*L. bohar & L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	P	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	P	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.	P	Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish	M	Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	P	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	M	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent	P	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			
BECH-DE-MER	NOJINAVUL			
LOLLY FISH				
GREEN FISH		*S. chloronatus*		
BLACKTIT				

NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugong dugon*		Mammalia
TURTLES	NEWU			Reptilia

MA1-T2

Marine Resource Baseline Survey of Crab Bay/Amal

LocationL: AMAL				
Name of Area: largest mangrove island on Amal reef @ 16 09.434 S; 167 31.501 E				
Date: DEC. 7/04	1430 h	drying tide (high @ 1200 h)		
Habitat Type	mangrove (mainly *R. stylosa*) thicket on sand, coral rubble, seagrass reef flat			
limited vizibility	mangal exposed on SE side; NW side protected from SE wind @ 15 knots			
TRANSECT #	**MA1-T2**	COMMENTS (fish listed indicates main sp. observed)		
FISH			**REL. ABUND.**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines	P	Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish	M	Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses (*Choerodon anchorago*)	S	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres oyena* & *G. acinaces*	PP	Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.	S	Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish		Scaridae
RED MAOT	MENGA	Emperors - *L. harak*	P	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L. fulvus* & *L. semiscinctus*	M	Lutjanidae
L. monostigma			P	Lutjanidae

L. erhenbergi			P	Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper - *L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	M	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	P	Nemipteridae
CARDINAL FISH		Cardinal fish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet	P	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent	PP	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.	S	Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*	S	Teraponidae
THICKLIP	REWUN			
BECH-DE-MER	NOJINAVUL			
LOLLY FIS				
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugon dugon*		Mammalia
TURTLES	NEWU		COMMON	Reptilia
OTHERS		SHRIMP - 1000s among	PP	

mangroves			
Mangrove moray		S	Muraenidae
Reef heron		20	

MA2-T2

Marine Resource Baseline Survey of Crab Bay/Amal

Location: AMAL

Name of Area: largest mangrove island on Amal reef @ 16 09.434 S; 167 31.501 E

Date:Feb 2/05 1200 h drying tide (high @ 1100 h)

Habitat Type *R. stylosa* thicket on sand, coral rubble, seagrass reef flat

Light west wind

TRANSECT #	**MA2-T2**	COMMENTS (fish listed indicates main sp. observed)		
FISH			**REL ABUND.**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish	M	Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses (*Choerodon anchorago*)		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	*Geres oyena* & *G. acinaces*	P	Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish -		Scaridae
RED MAOT	MENGA	Emperors - *L. harak*	M	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snapper - *L. fulvus*	S	Lutjanidae
L. monostigma			P	Lutjanidae
L. erhenbergi			P	Lutjanidae

(*L. argent*. & *L. bohar*)	DOAME	*L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	S	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	P	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.	S	Balistidae
MULLET	NANES(B);NAMBUR(W); DEMAUR(Y)	Mullet	P	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	P	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	S	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels	S	Pomacentridae
*A. septemfas*ciatus	DEPAT	Banded Seargent	P	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*	M	Teraponidae
THICKLIP	REWUN			
BECH-DE-MER	NOJINAVUL			
LOLLY FIS			S	
GREEN FIS				
BLACKTIT				

NATALAE		Tridacnae	
KOWFISH	BURIS	*Dugon dugon*	Mammalia
TURTLES	NEWU		Reptilia
OTHERS			
			Muraenidae
		Reef heron - 3 nests;	
		1 - hatchling	

MA1-T3

Marine Resource Baseline Survey of Crab Bay/Amal

Location: AMAL

Name of Area: 'Trochus Control Site' - 16 09.226 S; 167 30.874 E

Date: DEC. 7/04 1530 h drying tide (high @ 1200 h)

Habitat Type Coral pavement to reef drop off; drop off 60–75 % coral coverage

Limited visibility within top 2-m due to mangrove influence (freshwater and nutrients)

TRANSECT #	**MA1-T3**	COMMENTS	**REL. ABUND.**	
FISH (Common Name)				
FISH				
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	M	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*	S	Labridae

MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish	P	Scaridae
RED MAOT	MENGA	Emperors	S	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper - *L. bohar* & *L. argent*.	S	Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	M	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	M	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish	S	Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish	P	Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	M	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae

BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			
BECH-DE-MER	NOJINAVUL			
LOLLY FIS				
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugon dugon*		Mammalia
TURTLES	NEWU		Common	Reptilia
Others		*Monostigma grandoculus*	S	Lethrinidae

MA2-T3

Marine Resource Baseline Survey of Crab Bay/Amal

Location: AMAL	**ebbing tide (high @ 1300 h)**	**1515 h**		
Name of Area:'Trochus Control Site' - 16 09.226 S; 167 30.874 E				
Date: Feb.2/05	Limited vizibility within top 2 m due to freshwater influence			
Habitat Type	Coral pavement to reef drop-off; drop-off 60–75% coral coverage			
Drop off with spur & groove; swim throughs and caves - some sand				
TRANSECT #	**MA2–T3**	COMMENTS	**REL. ABUND.**	
FISH				
LOCHE	MBWETY	Groupers	S	Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish	M	Holocentridae
SARDINES	DANIV	Sardines	S	Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids

MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	PP	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish	PPP	Scaridae
RED MAOT	MENGA	Emperors		Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma			P	Lutjanidae
L. erhenbergi				Lutjanidae
(L. argent. & L. bohar)	DOAME	Snapper- *L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	S	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	PP	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish- *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet	P	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish	PPP	Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	P	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.	P	Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	P	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae

A. septemfasciatus	DEPAT	Banded Seargent	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.	Kyphosidae
SHARK			Carcharhidae
BARRACUDA	NUL		Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*	Teraponidae
THICKLIP	REWUN		
BECH-DE-MER	NOJINAVUL		
LOLLY FIS			
GREEN FIS			
BLACKTIT			
NATALAE		Tridacnae	
KOWFISH	BURIS	*Dugon dugon*	Mammalia
TURTLES	NEWU		Reptilia
Others		*Monostigma grandoculus*	Lethrinidae

MA2-T4

Marine Resource Baseline Survey of Crab Bay/Amal

Location: AMAL

Name of Area: Exposed Reef Drop-off; 16 09.145 S; 167 31.756 E

Date: Feb 2/05	1445 h	ebbing tide;light west wind

Habitat Type: Fringe reef drop-off; spur & groove, sloping, many plate corals

Freshwater springs=plankton bloom; macro-zooplankton; ctenophores, salps, etc.

TRANSECT #	**MA2-T4**	COMMENTS	**REL. ABUND.**

FISH (Common Name)

FISH

LOCHE	MBWETY	Groupers	S	Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish	S	Holocentridae
SARDINES	DANIV	Sardines	P	Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	P	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
KARONG	MEJUN	Trevally - *Caranx melampygus*	S	Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish - *Scarus* spp.	P	Scaridae
RED MAOT	MENGA	Emperors	M	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L. fulvus*, *L. gibbus*	P	Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
Macolor niger		Snapper - juv and adults	S	Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	S	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.		Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish - *B.viridescens*	S	Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish - *A. lineatus*	P	Acanthuridae
CONVICT	MOUWIT	*Acanthurus triostegus*		Acanthuridae

SURGEON				
SANDPAPER	VARLO	Unicornfish - *Naso* spp.	M	Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	M	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA		S	Haemulidae
DAMSEL	NI NURI PIPI	Damsels	M	Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents	M	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.	M	Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			
BECH-DE-MER	NOJINAVUL			
LOLLY FIS				
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugon dugon*		Mammalia
TURTLES	NEWU			Reptilia
Others		*Monotaxis grandoculus*		Lethrinidae
		Caesio spp.		Caesionidae

Crab Bay results

The transect designations are as follows; CB= Crab Bay; 1 or 2 refers to the two different sampling periods – 1was between Dec.6 & 9/04; 2 was between Feb.2-3/05; T1 – T-8 refers to individual transect numbers; if a given transect was sampled twice in the same period it is designated as TX-X-2.

These sites are all shown in Figure XXX indicating the location of Marine Sampling Sites. The designation on the map however exclude the 1 or 2

associated with the time of sampling, eg, they would indicate MCBT1, not MCB1-T1.

MCB1-T1

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY

Name of Area: Drop off .51N of PT. BRG 182; 16 09.574 S 167 32.094 E

Date: DEC. 8/04	1430h (15–20 Knot winds - rough sea)			
Habitat Type	Coral reef drop off; 10–20% coral cover			
	poor visibility			
TRANSECT	**MCB1-T1**		**REL**	
FISH			**ABUND**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish	S	Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	S	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish	P	Scaridae
RED MAOT	MENGA	Emperors	S	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L. semiscinctus*	P	Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae

(*L. argent.* & *L. bohar*)	DOAME	*L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	S	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	S	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.	S	Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish	P	Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	S	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.	S	Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	M	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp – 3 others	DEPAT BWI	Abudefduf spp.- Seargents	S	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SAK		Shark		Carcharhidae
SAWFIS	NUL	Barracuda		Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN		S	Haemulidae
BECHE-DE-MER	NOJINAVUL			
LOLLY FIS				
			S	
NATALAE				
NATALAE			S	
KOWFISH				Mammalia
TURTLES				Reptilia

MCB2-T1

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY

Lite NW wind

Name of Area: Drop off .51N of PT. BRG 182

16 09.574 S 167 32.094 E

Date: Feb.3/05 1630 h - ebbing tide

Habitat Type Coral reef drop-off, 10–20% coral cover with sand substrate at depth

poor visibility due to freshwater/mangal influence

TRANSECT	**MCB2-T1**		**REL.**	
FISH			ABUND.	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish	M	Holocentridae
SARDINES	DANIV	Sardines	P	Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	M	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish	P	Scaridae
RED MAOT	MENGA	Emperors		Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma				Lutjanidae

L. erhenbergi				Lutjanidae
(L. argent. & bohar)	DOAME	*L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	P	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	M	Nemipteridae
CARDINAL FISH		Cardinal fish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.	M	Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	M	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	P	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels	P	Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents	P	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SAK		Shark		Carcharhidae
SAWFIS	NUL	Barracuda		Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			Haemulidae
BECHE-DE-MER	NOJINAVUL			
LOLLY FIS				

GREENFISH		*S. chloronotus*	
NATALAE			
NATALAE			
KOWFISH			Mammalia
TURTLES			Reptilia

MCB1-T2

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY				
Name of Area: Drop off .7N of PT. BRG 180		**16 09.406 S 167 32.114 E**		
Date: DEC. 8/04	1500 h - poor visibility - rough seas, wind 15 knots			
Habitat Type	Coral reef drop off; 10–20% coral cover			
TRANSECT	**MCB1-T2**			
		COMMENTS	REL ABUND	
FISH				
LOCHE	MBWETY	Groupers	S	Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	S	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae

CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish	M	Scaridae
RED MAOT	MENGA	Emperors		Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L semiscinctus* & *L. fulvus*	S	Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper - *L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.		Mullidae
BIG EYE	METER PANG	Spinecheeks *Scolopsis* spp.		Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish	S	Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish *Rhinecanthys* spp.	S	Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish	P	Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	M	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	M	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae

A. septemfasciatus	DEPAT	Banded Seargent	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.	Kyphosidae
SAK		Shark	Carcharhidae
SAWFIS	NUL	Barracuda	Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*	Teraponidae
THICKLIP	REWUN		Haemulidae
BECH-DE-MER	NOJINAVUL		
LOLLY FIS			
GREEN FIS		S	
BLACKTIT			
NATALAE		Tridacnae	
KOWFISH	**BURIS**	*Dugong dugon*	Mammalia
TURTLES	**NEWU**		Reptilia

MCB2-T2

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY	**lite NW wind - on leeward side of reef; exposure limited**	
Name of Area: Drop off .7N of PT. BRG 180		**16 09.406 S 167 32.114 E**

Date: Feb. 3/05; 1500 h

Habitat Type Fringe reef drop off; 10–20 % coral cover some sand substrate; some freshwater influence; limited vizibility

TRANSECT	**MCB2-T2**	**REL. ABUND.**
FISH		

LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish	S	Holocentridae
SARDINES	DANIV	Sardines	P	Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses	P	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish	P	Scaridae
RED MAOT	MENGA	Emperors		Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers	M	Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	P	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.		Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish	S	Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.	P	Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH; NATIV	Surgeonfish	P	Acanthuridae

CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	P	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.	M	Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	P	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels	P	Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents	M	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SAK		Shark		Carcharhidae
SAWFIS	NUL	Barracuda		Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			Haemulidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS			M	
GREEN FIS			P	
BLACKTIT				
NATALAE		*T. crocea*	S	Tridacnae
KOWFISH	BURIS	*Dugong dugon*		Mammalia
TURTLES	NEWU			Reptilia

MCB1-T3

Marine Resource Baseline Survey of Crab Bay/Amal

Location: Crab Bay - Trochus outplant site - 16 09.772 S; 167 32.807 E

Name of Area: Trochus Outplant Site - Transect approx 300 m

Date**:** Dec.6/04 1430 h

Habitat Type**:** mixed coral pavement seaward changing to seagrass, coral rubble landward

Ebbing tide, sea very shallow over reef top; limited diversity & abundance due to habitat & low-ish tide

TRANSECT # **MCB1-T3** green turtles commonly seen in area

FISH (Common Name)

FISH			**REL. ABUND.**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
KARONG	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish		Scaridae
RED MAOT	MENGA	Emperors		Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae

(*L. argent*. & *L. bohar*)	DOAME	Snapper		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish *Parupeneus* spp.		Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.		Nemipteridae
CARDINAL FISH		Cardinal fish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish *Rhinecanthys* spp.	P	Balistidae
MULLET	NANES	Mullet	M	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks	P	Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*	P	Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp.- Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae

THICKLIP	REWUN			Haemulidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS			S	
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugong dugon*		Mammalia
TURTLES	NEWU		M	Reptilia

MCB1-T4

Marine Resource Baseline Survey of Crab Bay/Amal

Location: Crab Bay

Name of Area: Large *R. stylosa* complex at shore - 16 09.737 S; 167 32.468 E

Date: Dec.8/04 1500 h

Habitat Type Large Mangrove Tree at shore creating a complex of stilt roots with seagrass beds adjoining; strong tide flowing into area & freshwater seepage

TRANSECT #	**MCB1-T4**	**Comments** species listed=main sp. observed		
			REL	
FISH			**ABUND**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupeidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish - *S. fuscescens*	S	Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.	M	Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae

MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres oyena*	P	Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.	S	Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish		Scaridae
RED MAOT	MENGA	Emporers - *L. harak*	P	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L. fulvus* (juv.)	P	Lutjanidae
L. monostigma			P	Lutjanidae
L. ehrenbergi			P	Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	*L. argententamiculatus*	S	Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.		Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.		Nemipteridae
CARDINAL FISH		*Sphaeramia orbicularis*	M	Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerffish *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet - *Crenimugil crenilabis*	M	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	S	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent - incl.	P	Pomacentridae

		juv.		
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp.- Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*	S	Teraponidae
THICKLIP	REWUN			Haemulidae
STINGRAY		1 large	S	Dasyatidae
POSEN FIS		*Plotosus lineatus* – 1 school	P	Plotosidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS			S	
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugong dugon*	Mammalia	
TURTLES	NEWU		Reptilia	

MCB2- T4

Marine Resource Baseline Survey of Crab Bay/Amal

Location: Crab Bay		
Name of Area: 16 09.737 S; 167 32.468 E		
Date:	Feb.3/05; 1330 h	Ebb tide starting
Habitat Type	large *R. stylosa* creating a complex of stilt roots with seagrass beds adjoining and some freshwater seepage	
TRANSECT #	**MCB2-T4**	

REL.

FISH			**ABUND.**	
LOCHE	MBWETY	Groupers – 1 juv (*E. maculatus*)	S	Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.	M	Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres oyena*	P	Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish		Scaridae
RED MAOT	MENGA	Emperors - *L. harak*	P	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L. fulvus*	M	Lutjanidae
L. monostigma			M	Lutjanidae
L. erhenbergi			M	Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish	M	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	S	Nemipteridae
CARDINAL FISH		Cardinal fish - *Sphaeramia orbicularis*	P	Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet - White one	M	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae

CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	S	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent - incl. juv.	P	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL	Juveniles	S	Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*	S	Teraponidae
THICKLIP	REWUN			Haemulidae
STINGRAY				Dasyatidae
POSEN FIS		*Plotosus lineatus*		Plotosidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS				
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnia		Tricadnaea
KOWFISH	BURIS	*Dugong dugon*		Mammalia
TURTLES	NEWU			Reptilia
OYSTERS			S	

MCB1-T5

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY

Name of Area: Large stand of *A. marina* just west of T4

Date:	Dec.8/04	1545 h		
Habitat Type	Large stand of *A. marina* with sand and seagrass beds seaward extensive freshwater seepage			
TRANSECT #	**MCB1-T5**	**Comments** (fish listed are main sp. observed)		
FISH			REL ABUND	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres oyena* - juv	P	Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish		Scaridae
RED MAOT	MENGA	Emperors - *L. harak*	M	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	*L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.		Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.		Nemipteridae
CARDINAL FISH		Cardinal fish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae

KALA		Triggerfish - *Rhinecanthys* spp.		Balistidae
STRONSKIN	NASUMB			
MULLET	NANES	Mullet	S	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			Haemulidae
STINGRAY				Dasyatidae
POSEN FIS				Plotosidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS			S	
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugong dugon*		
TURTLES	NEWU			

MCB2-T5

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY

Name of Area: large stand of *A. marina* just west of T4; Transect approx. 50-m

Date: Feb.3/05; 1400 h

Habitat Type: large stand of *A. marina* with mud & sand/seagrass beds seaward extensive freshwater seepage; no strong current-ebbing tide

TRANSECT #	**MCB2-T5**		**REL. ABUND.**	
FISH	**URIPIV**			
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - Selar spp.		Carangidae
SILVA FIS	MARI	Mojarra – *Gerres oyena*. - juv.	P	Gerreidae
CARANGUE	MEJUN	Trevally – *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish -		Scaridae
RED MAOT	MENGA	Emporers - *L. harak* juv & adult	P	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L. fulvus - juv*	S	Lutjanidae
L. monostigma			M	Lutjanidae
L. erhenbergi			M	Lutjanidae

(L. argent. & *L. bohar*)	DOAME	Snapper		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish	M	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	S	Nemipteridae
CARDINAL FISH		Cardinal fish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Trigger fish		Ballistidae
KALA STRONSKIN	NASUMB	Trigger fish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet - *Ellochelon vaigiensis*	P	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish - juv.	S	Belonidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			Haemulidae
STINGRAY				Dasyatidae
POSEN FIS				Plotosidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS				
GREEN FIS				

BLACKTIT		
NATALAE		Tridacnae
KOWFISH	BURIS	*Dugong dugon*
TURTLES	NEWU	

MCB2-T6

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY 16 10.295 S; 167 31.899 E

Name of Area: smaller island of *R. stylosa* off CB Pt.(S of T7) "ACCESS AREA"

Date: Feb.3/05; 1200 h low tide

Habitat Type: mangrove with sand substrate & 3 types of seagrass - some freshwater influence; some *Sonneratia alba* trees; no large schools of fish; fish very wary

TRANSECT #	**MCB2-T6**			
FISH			**REL. ABUND.**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines	S	Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.	S	Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrot fish -		Scaridae
RED MAOT	MENGA	Emporers - *L. harak*	S	Lethrinidae

SNAPA FIS	MENGA NE DISMOT	Snappers -		Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper - *L. bohar* & *L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Juv - *Mulloidichthys vanicolensis*	S	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	S	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish -		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels -		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent	S	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			Haemulidae
STINGRAY				Dasyatidae
POSEN FIS				Plotosidae

BECH-DE-MER	NOJINAVUL		
LOLLY FIS			
GREEN FIS			
BLACKTIT			
NATALAE		Tridacnae	
KOWFISH	BURIS	*Dugong dugon*	COMMON
TURTLES	NEWU		COMMON

MCB2-T7

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY 16 10.232 S; 167 31.812 E

Name of Area: small island of R. stylosa off CB Pt. – "ACCESS AREA"

Date: Feb.2/05; 1630 h low tide

Habitat Type: mangrove with sand substrate & seagrass - freshwater influence
limited fish pop & diversity likely affected by low tide in addition to fishing pressure

TRANSECT #	**MCB2-T7**			
FISH			**REL. ABUND.**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish	P	Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	Wrasses		Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae

MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
CARANGUE	MEJUN	Trevally – *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrot fish -		Scaridae
RED MAOT	MENGA	Emporers -		Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers -		Lutjanidae
L. monostigma				Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAM	Snapper - *L. bohar & L. argentimiculatas*		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	S	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	S	Nemipteridae
CARDINAL FISH		Cardinalfish - Sphaeramia spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet	S	Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	Abudefduf spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae

BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			Haemulidae
STINGRAY				Dasyatidae
POSEN FIS				Plotosidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS			S	
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	BURIS	*Dugong dugon*	2	COMMON
TURTLES	NEWU			COMMON

MCB2-T7-2

Marine Resource Baseline Survey of Crab Bay/Amal

Location;	CRAB BAY	16 10.232 S; 167 31.812 E	
Name of Area; small island of R. stylosa off CB Pt. – "ACCESS AREA"			
Date:	Feb.3/05; 1300 h	high tide @ 1300 h	
Habitat Type:	mangrove with sand substrate & three types of seagrass - freshwater influence		
Lite west wind; clear sky			
TRANSECT #	**MCB2-T7-2**		

			REL.	
FISH			**ABUND.**	
LOCHE	MBWETY	Groupers		Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish		Holocentridae
SARDINES	DANIV	Sardines	S	Clupidae

PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU-Bilbil Waring	Wrasses - *Choerodon* spp.	S	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*		Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.	S	Gerreidae
CARANGUE	MEJUN	Trevally - *Caranx* spp.		Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrotfish		Scaridae
RED MAOT	MENGA	Emporers - *L. harak*	S	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers		Lutjanidae
L. monostigma			M	Lutjanidae
L. erhenbergi			M	Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper		Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Juv - *Mulloidichthys vanicolensis*	S	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.	S	Nemipteridae
CARDINAL FISH		Cardinalfish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish - *Rhinecanthys* spp.		Balistidae
MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae & Hemiramphidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish		Acanthuridae
CONVICT SURGEON	MOUWIT	*Acanthurus triostegus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.		Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish		Chaetodontidae
SWEETLIPS	NIKOR KOR VILA			Haemulidae

DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent	S	Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents		Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.		Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL	Juveniles	S	Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN			Haemulidae
STINGRAY				Dasyatidae
POSEN FIS				Plotosidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS			S	
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	**BURIS**	*Dugong dugon*		COMMON
TURTLES	**NEWU**			COMMON
OYSTERS			S	

MCB2-T8

Marine Resource Baseline Survey of Crab Bay/Amal

Location: CRAB BAY 16 09.716 S; 167 32.875 E

Name of Area: Outside of 'Trochus' reseeding site - 50-M TRANSECT

Date: Feb.3/05; 1530 h ebbing tide- lite NW wind

Habitat Type: Fringe Reef drop-off to > 10 m; exposed to SE tradewinds. Zooplankton bloom with abundant ctenophores & other un-identified zooplankton

Coral cover 60–80%; high diversity of large fish

TRANSECT #	**MCB2-T8**		**REL. ABUND.**	
FISH				
LOCHE	MBWETY	Groupers	M	Serranidae
REDFIS	MBWETY VAVAL	Soldier & Squirrelfish	S	
SARDINES	DANIV	Sardines		Clupidae
PORCUPINE FISH	DAUT	Porcupinefish		Diodontidae
PICOT	DECK	Rabbitfish		Siganids
MUDSKIPPER	DEMBKUTKUT	*Periopthalmus* spp.		Gobidae
WRASSE	NALIVU	*Epibulus insidor*	P	Labridae
NAPOLEON	DUDWI	*Cheilinus undulatus*	S	Labridae
MANGARU	JELEL	Big Eye Scads - *Selar* spp.		Carangidae
SILVA FIS	MARI	Mojarra - *Geres* spp.		Gerreidae
KARONG	MEJUN	Trevally - *Caranx melampygus*	M	Carangidae
BLUFIS	MELAIJ (Bl),NULIV (W), NAMER (Br)	Parrot fish - *Scarus* spp.	PP	Scaridae
RED MAOT	MENGA	Emperors	M	Lethrinidae
SNAPA FIS	MENGA NE DISMOT	Snappers - *L. fulvus*, *L. gibbus*	P	Lutjanidae
L. monostigma			M	Lutjanidae
L. erhenbergi				Lutjanidae
(*L. argent*. & *L. bohar*)	DOAME	Snapper - *L. bohar*	S	Lutjanidae
MOUSTAS FIS	NABUNMIREK/SURLIW	Goatfish - *Parupeneus* spp.	P	Mullidae
BIG EYE	METER PANG	Spinecheeks - *Scolopsis* spp.		Nemipteridae
CARDINAL FISH		Cardinal fish - *Sphaeramia* spp.		Apogonidae
STRONG SKIN	NABU	Triggerfish		Ballistidae
KALA STRONSKIN	NASUMB	Triggerfish- *Rhinecanthys* spp.	M	Balistidae

MULLET	NANES	Mullet		Mugilidae
LONGMAOT	NESIRAIR(B);DEWABUN(S)	Needlefish & Halfbeaks		Belonidae
NAEFIS	NEWRILING;BOLVE;NIMETH;NATIV	Surgeonfish	P	Acanthuridae
CONVICT SURGEON	MOUWIT	*A. lineatus*; *A. xanthopherus*		Acanthuridae
SANDPAPER	VARLO	Unicornfish - *Naso* spp.	M	Acanthuridae
BATAFLAE FIS	NION DRER	Butterflyfish	P	Chaetodontidae
SWEETLIPS	NIKOR KOR VILA	*P. lineatus*;	M	Haemulidae
DAMSEL	NI NURI PIPI	Damsels		Pomacentridae
A. septemfasciatus	DEPAT	Banded Seargent		Pomacentridae
A. spp - 3 others	DEPAT BWI	*Abudefduf* spp. - Seargents	M	Pomacentridae
BIG BEL	NIRA KO	Rudderfish - *Kyphosis* spp.	M	Kyphosidae
SHARK				Carcharhidae
BARRACUDA	NUL			Sphyraenidae
RICEFISH		Grunter - *Terapon jarbua*		Teraponidae
THICKLIP	REWUN	*P. chaetodonoides*	M	Haemulidae
STINGRAY				Dasyatidae
POSEN FIS				Plotosidae
BECH-DE-MER	NOJINAVUL			
LOLLY FIS				
GREEN FIS				
BLACKTIT				
NATALAE		Tridacnae		
KOWFISH	**BURIS**	*Dugong dugon*		COMMON
TURTLES	**NEWU**		1 GREEN	COMMON

Annex 11. Crab Bay Shellfish Survey Results

URIPIV	HABITAT	USE	Genus	species	COMMENTS
Baeik	Reef	food/vt	*Turbo*	*marmoratus*	Green snail
Banu	Mud	food/vt	*Anodontia*	*philippiana*	deep in mud in mangals
Bilwokwok	Reef	food/dish	*Tridacna*	*gigas*	extirpated in Vanuatu
Bolanial	Sand	Food			sea urchin sample
Botdrum	Reef		*Hippopus*	*hippopus*	Natalae
Botlar	Reef/Sand	Food	*Conus*	sp.	cone shell
Bulmin	Reef	decorative	*Cypraea*	sp.	larger cowrie
Bumbu	Reef	food	*Thais*	*armigera*	cleans belle'
Burtawu	drop-off	food/vt	*Cassis*	*cornuta*	
Dar-uer	Sand	food/vt			
Dawu	Sand	food/vt	*Charonia*	*tritonis*	Bubu shell; wu = blow
Delburong	Reef dropoff	food/vt	*Tridacna*	*crocea?*	Natalae
Dewik	Sand/mud	grater			spoon blong pikinini
Dirong	Mud/Mangal	food/vt	*Polymesoda?*	*erosa*	scratch banana, coconuts
Divut	reef	food/sell	*Acanthopleura spp.*		Chiton
Lel-wejur	drop-off	food/vt	*Tectus*	*pyramis*	
Leorgatu	Sand/mud	food/grater	*Anadara*	sp.	same as 26
Li-wae bae	open sea		*Lepas*	sp.	goose barnacle floated ashore
Melewev	Mud	food/vt			
Nakow	Reef	food/vt			
Nalel	Reef	food/vt	*Trochus*	*niloticus*	
Namer	Reef	food/vt			shell is flash to sell
Narbaso	mangroves	food/vt	*Saccostrea*	*cucculata*	mangal oyster
Nar-baso	Reef	food			

Nar-dawhu	Reef	food			Rare
Nari	Reef	necklace	*Cypraea*	sp.	small cowrie- handicrafts
Narman	Reef	grater			same as 4
Narmen	Reef	food			
Nar-nasi	Reef	grater			
Nar-Pirpir	Reef	food/vt			
Nar-walus	Sand	food			
Nar-wolu	anyplace	food	*Lioconcha?*	sp.	wolu=can move
Narwulu	reef	food			Abalone
Nases	Reef	food/vt			
Naso	Reef	food			
Nebir	Sand	food/vt	*Chione*	*undulata?*	produces a pearl
Nelil	Reef		*Turbo*	spp.	smol big eye
Nirang	Reef/Sand	food	*Lambis*	*lambis*	spider shell
Ni-tawil	drop-off	food/vt	*Atrina*	*vexillum*	big black shell; dish
Nuwag	Sand/mud		*T.*	*squamosa?*	Natalae
Nuwar	Sand/reef	food/vt	*Nautilus*	sp.	small drum; bubu shell
Patu-ni-tawil	Reef drop-off	Food/ scraper	*Pinctada*	sp.	pearl oyster
Sasurong	mangroves				nases blong natongtong
Serwok	Mud	grater/vt			
Sesmot	Reef	food/vt			
	Reef	Food	*Tonna*	*perdix*	Ton shell
	Sand		*Pinna*	sp.	Pen shell

Species identifications should be considered provisional

Annex 12: Community-based Coastal Monitoring Plan

In order to assess the impacts on resources and habitat of a long-term taboo on the resources of the Crab Bay area, it will be useful to monitor the changes that occur. As rigorous quantitative monitoring is a relatively new approach to resource management for rural community members, it is important to be at an appropriate level in order for it to be sustainable. The methodologies for monitoring outlined in this Ecological Baseline Survey for terrestrial crabs, mangroves and terrestrial flora, fish and other resources were designed with this in mind. As these techniques become more familiar and their value in monitoring changes in resources becomes apparent, these monitoring techniques can be added to and adapted to give more detailed information required. This process may be assisted by the RFDP and Forestry officers available in Lakatoro.

One of the greatest indicators of the rebounding of resources is increased catch rates and relative size of resources caught. This sort of qualitative monitoring has been going on since ancient times, and should not be overlooked as remaining useful. As the terrestrial areas, waters, mangroves and reefs of the middle part of Crab Bay are open to fishing and crabbing, this presents a good opportunity for fishers to observe the changes in catch in terms of numbers, size and composition. Regular interviews with fishers regarding perceived changes to their catches in relation to historical catches will also be useful in documenting the impact of the taboo on resources in Crab Bay.

Recommended Indicator Species and their Management within the AKTE

Land crabs (black and white)

Monitor burrow density, baited counts and timed counts as outlined in the Ecological Baseline Survey at select locations throughout the AKTE. These surveys should be repeated (at a minimum) bi-annually, once during the wet season and once during the dry season. More frequent monitoring would also be useful for detecting seasonal changes. It would also be useful to monitor the exact times and places of both white and black crab spawning aggregations, as these phenomena are poorly documented in Vanuatu. Knowing the times and places of crab spawning aggregations may be useful in controlling harvests at these locations during spawning periods.

Also monitor market sales of crab in the Lakatoro Market drawing upon the assistance of the Provincial employee that monitors market activity. If necessary, additional restrictions on harvests outside the AKTE during breeding season could be introduced and regulated through the market including the harvesting and sale of female crabs. Continue to promote and reinforce awareness regarding the negative impact of destructive collection techniques.

Mangroves

Monitor species composition, zonation changes and changes in size of areas with non-regeneration due to uplifting effects. Only harvest dead mangroves whenever possible. Produce a booklet on the mangroves of Crab Bay incorporating vernacular and scientific names and traditional uses to promote the retention and transmission of this knowledge.

Trochus

DoF survey's (including community training in stock assessment) by fisheries indicates significant increases in the trochus population of Crab Bay. An additional three year taboo is recommended to allow new recruits to obtain legal size of nine centimeters basal diameter. When monitoring indicates trochus stocks are sufficient for harvesting, strict adherence to size limit with short openings (1–2 weeks) during the cold season (when less reproduction is occurring) are recommended as ideal. Monitor weight of trochus sold/year for inter-annual comparison to monitor sustainability of harvest levels.

Reef fish

Monitor existing finfish stations/transects for changes to mangal and reef fish communities. Phase in Reef Check to fish monitoring with DoF support to cover more detail on invertebrates. Good to integrate the use of vernacular terms into Reef Check to assist with language skills and transmission. Restrict spearfishing and use of nets during hot season, especially during annual spawning migrations of rabbit fish (picot), mullet and mangaru (*Selar* spp.); restrict use of small mesh nets (1–2 finger) throughout year (except when targeting sardines).

Giant Clams (endangered species)

Create breeding circles for each species and monitor these for mortalities as well as recruitment of juvenile giant clams within Crab Bay.

Shellfish

Shellfish sold commercially could most easily be monitored through the Lakatoro market and those used for subsistence through interviewing shellfish collectors. Forms including date, vernacular term, place of origin (i.e. fishing area), fisher and quantity (e.g. basket, plastic bag or other appropriate unit) should be provided to the Provincial employee monitoring the Lakatoro Market activities (along with training in properly filling it out). These data should be collated at the DoF office in Lakatoro (or Port Vila) where they can be entered into a database or spreadsheet for analysis.

Turtles (endangered species)

Different turtle species are useful as indicator species due to their position in the food web and the relative ease with which they can be enumerated. The numbers of green turtles are indicative of seagrass coverage while hawksbill turtles are indicative of coral reef coverage. Monitor turtle numbers throughout year and also monitor nesting within the Crab Bay area. Also monitor feeding areas to reflect changes in seagrass coverage and coral cover.

Dugongs (endangered species)

Dugongs are also relatively easy to monitor due to their size and their numbers will also be indicative of seagrass coverage. Monitor number of dugongs, areas and seasons important for mating and calving; also changes in feeding areas to reflect changes in seagrass coverage.